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ABSTRACT

Developed to complement existing elementary science programs, the materials in this second volume of New York's Elementary Science Supplement emphasize an experiential, hands-on approach for children aged 7-9. Major sections include guidelines for program activities, (the format of this publication); correlating syllabus and program, (including a chart which correlates skills, processes and attitudes with the units of the program); and program activities, (indicating syllabus emphasis, problem overview, suggested approach, materials, discussion notes, and supplementary information for four units, four mini-units, and 16 unit-starters). Appendices include "Students with Handicapping Conditions" and a blank "Syllabus-Program Correlation Chart for Level II." Topics covered in this guide include buoyancy, electricity, life cycles, energy, and ecology. (CW)

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ELEMENTARY SCIENCE SUPPLEMENT TO THE SYLLABUS

Level II
(Ages 7 through 9)

May 1988

The University of the State of New York
The State Education Department
Albany, New York 12234

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FOREWORD

Elementary science teachers realize the importance of direct experience, hands-on activities as keys to good science teaching. The activities included in the three volumes of the *Elementary Science Supplement Syllabus* are suggested and not mandatory. The volumes are prepared in a format that will enable you to easily add to, or delete from, the contents.

Many elementary science teachers have an extensive personal repertoire of hands-on activities which will complement the syllabus approach. Teachers willing to share their activities with others are urged to make the Bureau of Science Education aware of their willingness to share. In some instances, activities may be incorporated directly for future publications of the volumes. In other instances, the activities may become a high priority for further development of refinement. Development and refinement may be able to receive local financial support through the BOCES CoSer process in some instances.

The Syllabus-Program Correlation Chart correlates the syllabus outcomes with the instructional activities. The correlation chart will also show areas in need of supplementary expansion. Teachers may wish to add their own classroom activities, field trips, multimedia materials, trade books or text materials to the charts, or to blank forms of the charts.

The Elementary Science Supplements to the Syllabus for Levels I and III are available from the State Education Department upon request.

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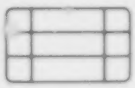
GUIDELINES FOR PROGRAM ACTIVITIES



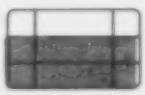
...effective program activities use a problem-solving approach...

PROGRAM CRITERION: Program activities will use a problem-solving approach.

PROGRAM ACTIVITIES are the teacher-planned activities you use with your students to teach them elementary science. These activities can cause students to encounter discrepancies.

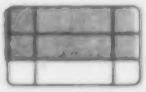
The program activities in this publication are organized into units, mini-units, and unit starters. You may use them for example:

- directly as part of your local elementary science program, or
- as supplements to a commercial program.



UNITS focus on a central problem or theme. They require from several days to several weeks to complete. Units contain the greatest amount of lesson plan detail and supplementary information. You can use the format for units as a standard to help you develop your own units from other activities.

MINI-UNITS also focus on a central problem or theme. However, compared with units, they usually require less time to complete (from a few days to a few weeks) and contain less supplementary information and lesson plan detail. The lesson plans are sufficient to give you direction and assistance, but you should expand them into units and fit them to your personal style and the needs of students before you use them.



UNIT STARTERS focus on a problem or question. Use them to stimulate ideas that lead students to a deeper investigation into a problem. Unit starters contain the least amount of lesson plan detail. You may want to develop detailed lesson plans yourself or use the unit starters to help your students construct a complete plan for solving a problem.

Because unit starters can take a wide variety of forms, they could require from a day to several weeks to complete.

Schodack Central School District

PROGRAM ACTIVITIES

UNITS

Each unit follows a standard format. The format is designed to be simple, informative, and comprehensive. You can use it to construct your own new units locally.

Components of the unit format are explained below and are illustrated by using annotated sample pages.

TITLE and/or **FOCUS QUESTION**

LEVEL indicates the level for which the unit is written. There is space to add the grade at which you will use it.

PROBLEM OVERVIEW provides the setting or context for the problem.

SUGGESTED SCHEDULE lists specific program activities in the recommended sequence for instruction. Time allotments shown are approximate amounts of class time needed to complete the activities.

SYLLABUS EMPHASIS indicates the cross-reference of each activity to the Skills, Science Attitudes, and Science Content sections of the syllabus. It includes only major connections to the syllabus. You may have additional outcomes from your particular activities.

SUGGESTED APPROACH provides an overview of the procedure you might use to conduct the unit.

BUTTERFLIES LEVEL II ____ (GRADE)

PROBLEM OVERVIEW

The butterfly is a common and colorful part of most children's experience with the natural world. Although many children may think they know a lot about butterflies, it is unlikely that they have had an opportunity to closely observe butterflies or to learn about their life cycle in a controlled environment. Consequently, the butterfly's life cycle may seem mysterious to them. This unit can provide the opportunity to remove some of the mystery by helping children gain a better understanding about and increased appreciation of another creature of the natural world.

SUGGESTED SCHEDULE SYLLABUS EMPHASIS

#	Activity Title	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Emphasis
1	Facts, Myths, and Questions							Making Decisions: Questioning A 1 1 Accurate information B A 2 1 Generation: stages: life cycle
2	Planning the Care of Butterflies							Making Decisions: Communicating Information A 1 21 Individual life: process B A 2 1 Generation: stages: life cycle
3	The Larvae							Observing: Recording Data A 1 12 Accurate information B A 2 1 Generation: stages: life cycle
4	Animals Depend on Plants							Predicting: Recording Data A 2 11 Uncertainty of information: certification B B 1 Plants: animal food supply: sun energy
5	Adult Traits							Observing: Communicating Information A 1 11 Complexity, diversity, interaction, etc. B A 2 1 Generation: stages: life cycle
6	The Adult							Observing: Communicating Information A 1 11 Complexity, diversity, interaction, etc. B A 2 1 Generation: stages: life cycle
7	Butterfly Eggs							Observing: Communicating Information A 1 12 Accurate information B A 2 4 Animal potential for offspring
8	Completion of the Life Cycle							Creating: Models: Classifying A 1 4 Understanding: natural world B A 2 1 Generation: stages: life cycle
9	Returning to the Natural Environment							Making Decisions: Communicating Information A 1 2 Respecting life B A Plants: animals: new generations

SUGGESTED APPROACH

Butterfly larvae must be ordered several weeks in advance. Larvae and culture medium are available from science supply houses. Since the painted lady butterfly can be grown easily in captivity, it is the species usually available and is the species used in this unit. The unit is best done in spring or fall when environmental conditions are better for butterflies.

Several weeks before the unit begins, consult the librarian to determine what books, computer software, and media materials about butterflies are available, with special emphasis on myths and superstitions. If possible, arrange for the materials to be delivered to the classroom or placed on reserve in the library. Include materials from a wide range of reading levels to provide background for students with varying abilities. The librarian may want to use butterflies as the focus for a required library skills unit.

The unit can start by having students pool the knowledge they already have or think they have, about butterflies. The listing of myths, superstitions, suppositions, and factual information can serve as discrepancies to be resolved. For example, students may be surprised by what arrives in the mail as the "ordered butterflies." Comparisons can and should be made with animals students have studied previously or animals with which they are familiar. Students can, for example, determine how butterflies are like or unlike mealworms.

MATERIALS are listed for the entire unit. Quantities shown are for class-size groups.

MORE IDEAS list other activities that you can use at your discretion to:

- extend the unit,
- enrich the unit, or
- reinforce learning outcomes.

MATERIALS

Cotton swabs — 1 bag
Nylon mesh — 4 sq. meters
Dropper bottles — 2
Granulated sugar — 1 1/2 pints
Cotton balls — 1 small bag
Petri dishes — 12 small
Hand lenses — 12
Plants: sprouts — 8
Culture containers with lids — 15
Butterfly larvae — 1 per 2 students
Butterfly culture medium — 1 pint
Filter paper or hair-setting tape
Paper punch
Paper clips
Paper fasteners
Cardboard boxes (approx. 40 x 30 x 25 cm) or shoe boxes — 6
Masking tape
Potting soil
Mallow plants and other plants
Box knife
Plastic aquarium
Plastic wrap
Scissors
String
Poster paper
Captured butterfly (by teacher) or pictures of butterflies
Rulers (centimeter scale)

MORE IDEAS

1. Check your local library to find books, filmstrips, pictures, computer software, etc. to supplement the classroom activities.

2. Have students collect poems about butterflies or moths for a poetry anthology.

3. Have students write their own poems about butterflies.

4. Conduct a discussion on survival, including the idea that not all living things will develop or live to reach maturity, and the limiting factors by which populations are controlled.

5. Create classroom bulletin boards of commercial and students' works.

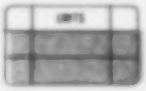
6. Have students develop reports, compositions, or visual presentations on butterflies, or have students write a book about butterflies. Include topics and ideas from the insect's viewpoint, such as "My First Flight," "Why My Antennae Are Knobbed," "How I Lost an Leg," etc. Students may also write a "wordless" book. Ruth Heller's book, *Butterflies*, is an example of a wordless book that provides a high content level.

7. Have students produce models of the insect's life cycle.

8. Conduct a guided imagery experience with students on how it feels to be a butterfly as it develops from egg to actual butterfly. Develop a visualization narrative and read it to students as a prewriting activity. (See "Guided Imagery in the Curriculum," by B. Cabezas, *Educational Leadership*, March, 1983, pp. 54-56.)

9. Have students plant a butterfly garden. Research which plants butterflies (including the caterpillar stage) feed on, then order seeds or small plants from a plant catalog or nursery. Check local gardens and open fields for plants that can be transplanted to the garden. Plant and tend the garden, then observe, record, and analyze what happens.

PROGRAM ACTIVITIES



SUPPLEMENTARY INFORMATION gives you additional information. It can include a materials list, safety notes, procedural notes, references to more ideas, preparation notes, and ways to integrate the activities with other areas such as art, music, and social studies.

ACTIVITIES provide directions for conducting the activity.

SYLLABUS EMPHASIS shows the connection between the activity and the syllabus.

PROBLEM states the problem in the form of a question that focuses inquiry.

CONCEPTS provide words that are symbolic of the main concepts dealt with in the activity. These key words are mainly for your own use. Therefore, you will need to decide your own students' readiness to use the words and the level at which you would expect your students to use them. For example, you might not use the word with them at all, or you might require only that they know how to spell it.

COMPONENT CONNECTION lists the major skills, science attitudes, and science principles that the activity brings together. It is a minimum cross-reference to the syllabus. You may wish to add other cross-references.

EVALUATION STRATEGY suggests a behavioral outcome for the activity and indicates the kind of evaluation you should make. The recommended kinds of evaluation are:

- Individual – evaluate each student,
- Group – base your evaluation on samplings of groups of students, and
- Program – evaluate the effectiveness of the activity by using either individual students or student groups.

Syllabus Emphasis	Activities	Supplementary Information
Problem: What facts, myths, and questions do people have about butterflies?	**1. FACTS, MYTHS, AND QUESTIONS**	**Materials:** Captured butterfly, pictures of butterflies for display, and resource materials
Concepts: butterfly caterpillar fact superstition myth pupa	 **Painted Lady Butterfly** A few days before larvae arrive, conduct a discussion with students about their experiences with butterflies. If possible, capture a butterfly to show to the class (then release it the next day). Otherwise, show numerous pictures of a butterfly. **Class Discussion:** After looking at the butterfly, what is your reaction? What is the first word that comes to your mind? Why do you think this word came to your mind? Make a chart of the words chosen by the students. Discuss the suggested words (possible words: beautiful, pretty, colorful). Use this list to describe the class attitude toward butterflies. Help students brainstorm what they already know about butterflies. Ask them to survey other students, teachers, and family members for myths and superstitions about butterflies. Make a master list of what students know (or think they know) about butterflies. What seems to be fact on the list? Myth? Superstition? How can we find out? Which items in the list do we want to find out more about? Determine if they are fact. What other questions do we have about butterflies? Which questions do we want to investigate? How will we decide which questions to investigate? How will we investigate these questions? What information do we already have? What new information do we need? What is our plan?	**Procedural Notes:** 1) This initial activity should serve to identify any discrepant information about butterflies which students have already acquired or which is noted as they share their knowledge about butterflies. Students may ask, "Is that (fact) really true?" or state, "I thought the opposite was true." The investigations students plan can then be used to confirm or reject what they classified as fact, or to answer questions raised. 2) Typical questions which students might raise are: What are the different kinds of butterflies? Where are butterflies found? What do butterflies eat? Can we raise butterflies in the classroom? How do we care for the butterflies? Where do butterflies come from? How is a butterfly different from a moth? What happens to a butterfly when it gets cold? Do butterflies migrate like birds? How does a butterfly change in form? What don't we know about butterflies? How does the class feel about caterpillars? What does a caterpillar eat? Are butterflies and caterpillars insects? How large is a butterfly's neighborhood? Why are butterflies called "butterflies?" While all student questions can be investigated, and students should be encouraged to investigate those of most interest to them, the remaining activities in this unit focus on the questions which can be pursued through direct classroom experiences with butterflies. 3) Small groups of students can be encouraged to investigate individual questions (which are really problems) in the master list, while the class as a whole works on other questions (problems), such as the following activities in this unit. A culminating activity might be a class sharing of what these small groups have learned about butterflies.
Skills Processes: **Inquiry:** Making Decisions • Students decide what questions about butterflies they will investigate. **Language Arts:** Questioning • Students develop a list of questions which indicate what they want to find out about butterflies.		
Science Attitudes: A-1.32 Wanting accurate and thorough information about the natural world. • Students raise questions about butterflies which are of interest to them.		
Science Understandings: II-A-2.1 Each generation of animals goes through changes in form from young to adult. The adult gives rise to the young of the next generation. This completed sequence of changes in form is called a life cycle. • Many student questions will focus on the changes a butterfly goes through during its life cycle.		
Evaluation Strategy: Group, Program Students are able to make decisions about which questions they want to investigate and to plan how they will investigate the questions they choose.		

Guilderland Central School District

PROGRAM ACTIVITIES

MINI-UNITS

Each mini-unit follows a standard format. The format is intended to be simple and informative but less comprehensive than the unit format. You can use it to construct your own new mini-units locally.

Components of the mini-unit format are explained below and are illustrated by using annotated sample pages.

TITLE and/or **FOCUS QUESTIONS**

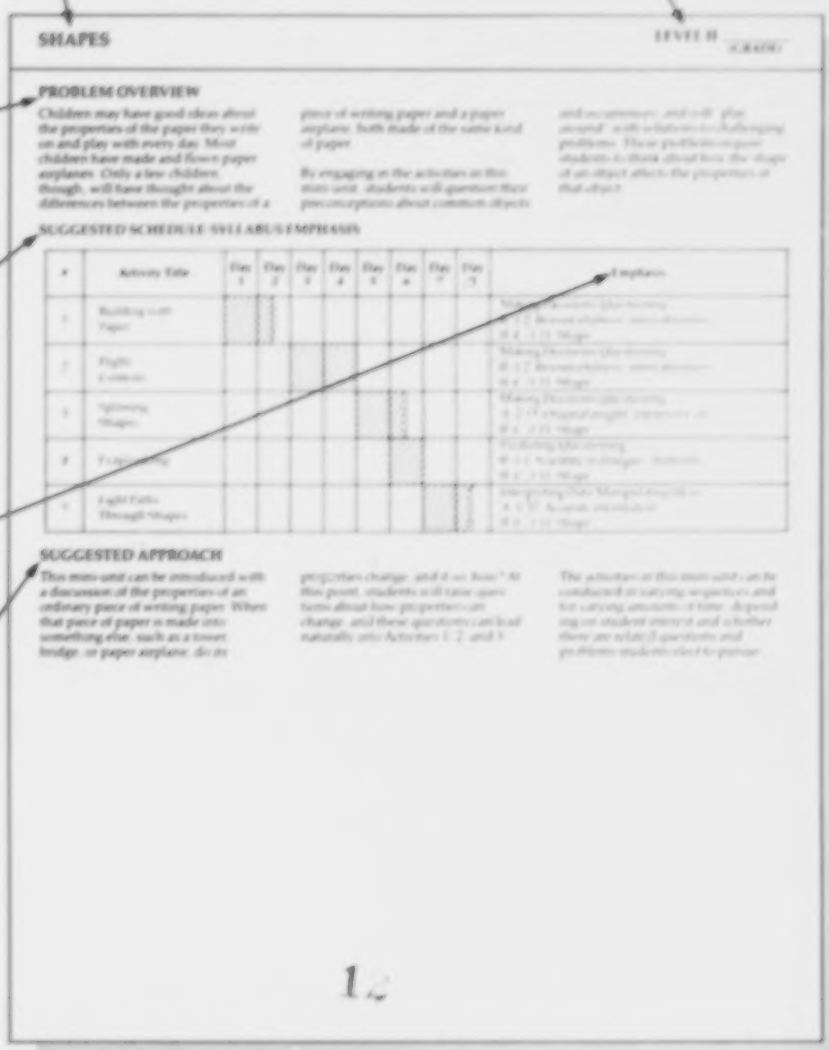
LEVEL indicates the level for which the mini-unit is written. There is space to add the grade at which you will use it.

PROBLEM OVERVIEW provides the setting or context for the problem.

SUGGESTED SCHEDULE lists specific program activities in the recommended sequence for instruction. Time allotments shown are approximate amounts of class time needed to complete the activities.

SYLLABUS EMPHASIS indicates the cross-reference of each activity to the Skills, Science Attitudes, and Science Content sections of the syllabus. It includes only major connections to the syllabus. You may have additional outcomes from your particular activities.

SUGGESTED APPROACH provides an overview of the procedure you might use to conduct the mini-unit.



SHAPES

LEVEL II

PROBLEM OVERVIEW

SUGGESTED SCHEDULE/SYLLABUS EMPHASIS

SUGGESTED APPROACH

MATERIALS

Scrap paper
Newspaper
Paper clips
Toothpicks
Eyedroppers
Water
Timer
Scissors
Floating ghosts or helicopter cutouts
Cylindrical containers (various widths)
Glass containers (various shapes)
Graduated cylinders or beakers
Hand lenses
Magnifying glasses
Large mounted magnifying glass
Discarded eyewear lenses
Camera lenses
Flashlights and penlights
Paper screen
Newsprint paper
Tape, cellophane

MORE IDEAS

1. Visit construction projects to learn more about the structural strengths of various materials as well as different construction techniques.

2. Research the various types of bridges. Have students build model bridges with toothpicks, glue, string, and cardboard. See how many books they will support.

3. Why is the arch a common design in structures?

4. Help students to construct tetrahedrons with mini marshmallows and toothpicks. How does the shape of a tetrahedron affect its strength? What structures can be built using tetrahedrons?

5. Find out how transatlantic cables were made.

6. Research the properties of the materials used in constructing aircraft and spacecraft.

7. Find out what some of the best paper airplane shapes are. Check *The Great International Paper Airplane Book*, by Mander, Dippel, and Gossage, 1967.

8. Visit a maple sugar house to see how maple syrup is made. How does the shape of the evaporating pans affect evaporation?

MATERIALS are listed for the entire unit. Quantities shown are for class-size groups.

MORE IDEAS list other activities that you can use at your discretion to:

- extend the mini-unit,
- enrich the mini-unit, or
- reinforce learning outcomes.

SUPPLEMENTARY INFORMATION contains a brief list of materials needed for the activity.

SYLLABUS EMPHASIS shows the connection between the activity and the syllabus.

ACTIVITIES provide brief directions for conducting the activity.

PROBLEM states the problem in the form of a question that focuses inquiry.

COMPONENT CONNECTION lists the major skills, science attitudes, and science principles that the activity brings together. It is a minimum cross-reference to the syllabus. You may wish to add other cross-references.

Syllabus Emphasis	Activities	Supplementary Information

Problem:
How strong is paper?

Making Decisions/Questioning	
B-1.2	Resourcefulness, innovativeness
II-C-1.11	Shape

1. BUILDING WITH PAPER

Ask students (in groups of 4) to use only one sheet of paper to support a book 8 1/2" above the floor or desk. (It can be done.) Using newspaper, students can try to support the book only at the ends and have it bridge across two desks.

Challenge each group of students to build the tallest structure possible from 10 sheets of paper and 10 paper clips. As another variation, have students build the largest bridge possible from 10 sheets of paper and 10 paper clips.

Conduct a discussion to help students understand how shape affects structural strength. Discuss some of the world's great construction challenges: bridges, tunnels, arches, skyscrapers.

Materials:
Scrap paper
Tape
Paper clips
Newspaper

Problem:
How does shape affect flight?

Making Decisions/Questioning	
B-1.2	Resourcefulness, innovativeness
II-C-1.11	Shape

2. FLIGHT CONTESTS

Use a large area such as the school gym or cafeteria – or an outside area, if there is little or no wind. Have students build airplanes from scrap paper and have contests for different flight categories, such as distance, flight time, and stunt flight. Students can experiment with design and the use of paper clips to seek solutions to the problems posed by the different flight categories.

Discuss the shapes of other objects which move through the air: footballs, baseballs, soccer balls, a javelin, a discus. Discuss how objects would move through an airless medium (vacuum).

Materials:
Scrap paper
Paper clips
Timer

Safety Note:
Provide for protection of eyes during airplane flight. Safety goggles or using only blunt-nosed airplanes are possible strategies.

Problem:
How does shape affect how paper helicopter cutouts fall?

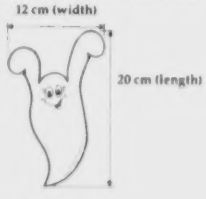
Making Decisions/Questioning	
A-1.13	Original insight, inferences, etc.
II-C-1.11	Shape

3. SPINNING SHAPES

Have students cut out a floating ghost or a helicopter drawn from the sketch provided. Let students drop the cutout several times. Then ask how they could turn the cutout into a spinning ghost or a helicopter. Allow students to try out their ideas.

Discuss with students the best way to make the cutout spin. How could they make the cutout spin faster? How could they make it fall

Materials:
Floating ghost or helicopter cutouts
Scissors
Paper clips
Paper



Floating Ghost

PROGRAM ACTIVITIES

UNIT STARTERS

Each unit starter follows a standard format. The format is designed to be brief, yet it contains enough information to stimulate many ideas for activities. You can use it to construct your own new unit starters locally.

Components of the unit starter format are explained below and are illustrated by using an annotated sample page.

FOCUS QUESTION represents the discrepancy underlying the problem and is presented in the form of a question.

LEVEL indicates the level for which the unit starter is written.

GRADE provides space for you to add the grade at which you will use it.

SYLLABUS CONNECTION contains a brief cross-reference of the activity to the Skills, Science Attitudes, and Science Content sections of the syllabus.

PROBLEM OVERVIEW provides the context in which the discrepancy can be encountered and the focus question identified.

UNIT STARTERS — LEVEL II

Grade Level	Syllabus Connection	Focus Question	Problem Overview
	Observing/Questioning A-2.12 II-C-2.2/II-D-2	Is that really you in the mirror?	Students may believe a mirror reflects their true appearance. Have students compare their mirror images to photographs of themselves. This comparison can lead to many questions about how light moves and how it is reflected.
	Predicting/Classifying A-1.11 II-C-2.1	What things do magnets attract?	Many students have played with magnets. Asking them to predict which objects can and cannot be attracted to a magnet focuses the problem. Students can then test their predictions and identify the properties common to magnetic material.
	Recording Data/Communicating Information B-2.2 II-D-1	What works in your kitchen?	Students are probably aware of the many appliances involved in food preparation and clean up. Home surveys and class brainstorming can focus attention on these appliances and may lead to further investigation of how they work and what types of energy they provide.
	Generalizing/Questioning A-2.12 II-C-2.2/II-D-2	Are fingers good thermometers?	Students usually assume that objects that feel cold have lower temperatures than objects that feel warmer. Have students feel several different surfaces (metal, wood, cloth, and paper) in the classroom and rank them from coldest to warmest. Use a thermometer to measure the temperatures of these surfaces, note discrepancies. Focus student discussion on the flow of heat from their fingers through the objects involved.
	Generalizing/Classifying A-1.33 II-C-2.2/II-D-1	How do objects make sound?	Students have learned to take the sounds they hear for granted. But what causes sounds to be produced? Ask students to play a song using their rulers and then to design some simple musical instruments. To focus the problem, investigate what these sound makers have in common.
	Manipulating Materials/Questioning A-2.13 II-D-1/II-D-2	Where does the energy go?	Rube Goldberg, a cartoonist, was famous for his sketches of complicated contraptions that performed simple jobs. Students can build a "Rube Goldberg" device that actually works, and use it to investigate energy transfers in a system. The challenge is to include the largest number of energy transformations and forms of energy and to have energy travel through space the greatest number of times. For example, devise an automatic balloon popper or a better mousetrap.

1.1

CORRELATING SYLLABUS AND PROGRAM

...appropriate problem-solving activities always correlate directly to the syllabus.

PROGRAM CRITERION: Program activities should always correlate directly to the skills, science attitudes, and science content defined in the syllabus.

The syllabus tells you what the State expects you to teach in elementary science. The Syllabus-Program Correlation Chart shows you which program activities you can use to teach a particular part of the syllabus.

An activity correlates to the syllabus if its expected outcome is the same as a desired outcome defined in the syllabus. Thus, in the illustration below, the program activity on "trees" correlates to the syllabus in that it teaches the skill of "questioning," the science attitude of "respect," and the science content of "seed dispersal."

You can use the Syllabus-Program Correlation Chart both with program activities you design yourself and with those you take from other sources. Once you have filled in the chart, you can use it to:

- provide a quick inventory of all program activities available,
- select appropriate program activities that will achieve specific syllabus outcomes, and
- determine which outcomes each program activity is expected to achieve.

You can also use the Syllabus-Program Correlation Chart:

- as a worksheet to determine the correlation to the syllabus of other instructional materials such as kits, field trips, media materials, trade books, and texts
- as an organizing sheet to help you develop a local sequence of instruction for each grade or each special grouping of students
- as an analysis sheet to help you answer such questions as:
  - — Are we teaching everything we should be teaching?
  - — Are we needlessly duplicating instruction between grades or levels?
  - — Are we providing enough reinforcement of outcomes within a grade or within a level?

SYLLABUS		ACTIVITY: BUOYANCY	TREES	CLOUDS	STREAM FIELD TRIP	MOVIE: MAPLE TREES	TEXT: CHAPTER 3				
SKILLS	CLASSIFYING			■							
	MEASURING				■						
	QUESTIONING	■	■				■				
	COMMUNICATING			■		■					
SCIENCE ATTITUDES	RESPECT		■			■	■				
	SAFETY				■						
	TRUTHFUL REPORTING	■									
	SERVICE						■				
SCIENCE CONTENT	MATERIAL SHAPE	■									
	ENERGY FORM			■	■						
	SEED DISPERSAL		■				■				
	STORED FOOD					■					

Blank correlation charts are included in Appendix G of the syllabus and in Appendix B of this publication. Wall-chart-size versions of the charts are also available from the State Education Department upon request.

SYLLABUS - PROGRAM CORRELATION CHART
LEVEL II – UNITS AND MINI-UNITS

ACTIVITIES

		UNIT										MINI-UNIT									
	Time Emphasis (Days)	BUOYANCY	BULBS, BATTERIES AND WIRES	BUTTERFLIES	PLANT LIFE CYCLE							SHAPES	ENERGY CHANGES	DANDELIONS	PLANTS AND ANIMALS – DEP						
INQUIRY SKILLS	CLASSIFYING				■																
	CREATING MODELS	■	■	■	■										■						
	FORMULATING HYPOTHESES	■	■		■										■						
	GENERALIZING														■						
	IDENTIFYING VARIABLES	■	■		■										■						
	INFERRING	■	■		■										■						
	INTERPRETING DATA											■	■	■							
	MAKING DECISIONS	■	■	■								■									
	MANIPULATING MATERIALS		■		■								■								
	MEASURING												■								
	OBSERVING		■	■	■								■		■						
	PREDICTING	■	■	■	■							■									
	RECORDING DATA																				
	REPLICATING																				
	USING NUMBERS																				
LANGUAGE ARTS SKILLS/ PROCESSES	CLASSIFYING	■		■																	
	DEVELOPING VOCABULARY		■																		
	MANIPULATING IDEAS											■			■						
	QUESTIONING	■	■	■	■							■			■						
	RECORDING DATA																				
	USING CUES																				
	ACQUIRING INFORMATION	■	■	■	■									■	■						
	COMMUNICATING INFORMATION	■	■	■	■							■	■	■	■						
SCIENCE ATTITUDES	A. APPRECIATING, ENJOYING, NATURE																				
	1. UNDERSTANDING, NATURAL WORLD			■																	
	1.1 APPRECIATING NATURAL WORLD			■										■							
	1.11 COMPLEXITY, DIVERSITY, INTRICACY, ETC.			■										■							
	1.12 RESOURCE, HUMAN NEEDS													■							
	1.2 RESPECTING LIFE			■	■																
	1.21 INDIVIDUAL LIFE, PRECIOUS			■	■										■						
	1.22 SOURCE FOR CONTINUATION																				
	1.23 AGING PROCESS																				
	1.3 WANTING TO KNOW, UNDERSTAND																				
	1.31 CONCEPTS, TERMS, TECHNIQUES, ETC.		■																		
	1.32 ACCURATE INFORMATION			■	■							■	■		■						
	1.33 EXPLANATIONS, INTERPRETATIONS, PREDICTIONS		■																		
	2. INVESTIGATIVE METHODS, NATURAL WORLD																				
	2.1 SKEPTICISM, INVESTIGATION, REASONING		■	■																	
	2.11 UNCERTAINTY OF INFORMATION, VERIFICATION	■	■	■										■							
	2.12 AMBIGUITY, CONTRADICTION, TENTATIVENESS												■								
	2.13 ORIGINAL INSIGHT, INFERENCES, ETC.											■									
	2.14 CAREFUL, SYSTEMATIC INVESTIGATION		■		■								■	■							
	2.15 LOGICAL REASONING, VALIDITY OF IDEAS	■																			
	2.2 RESPECTING OTHERS, ENVIRONMENT																				
	2.21 SAFETY		■																		
	2.22 USE OF RESOURCES																				
	2.23 CONTRIBUTING FAIR SHARE OF EFFORT	■																			
	2.24 CONTRIBUTIONS, OTHERS																				
	2.25 TRUTHFUL REPORTING		■																		
	2.26 BELIEFS AND VALUES OF OTHERS	■												■							
	B. VALUING USE OF KNOWLEDGE FOR SOCIETY																				
	1. THE PRACTICAL, TECHNICAL												■								
	1.1 SCIENTIFIC TECHNIQUES, MATERIALS				■							■									
	1.2 RESOURCEFULNESS, INNOVATIVENESS	■	■									■									
	1.3 TECHNIQUE EFFICIENCY, SIMPLICITY, ETC.		■										■								
	2. SERVICE THROUGH TECHNOLOGY																				
	2.1 NEEDS, PROBLEMS OF OTHERS																				
	2.2 BENEFITS OF TECHNOLOGICAL CHANGE																				
	2.3 POTENTIAL ADVERSE CONSEQUENCES																				

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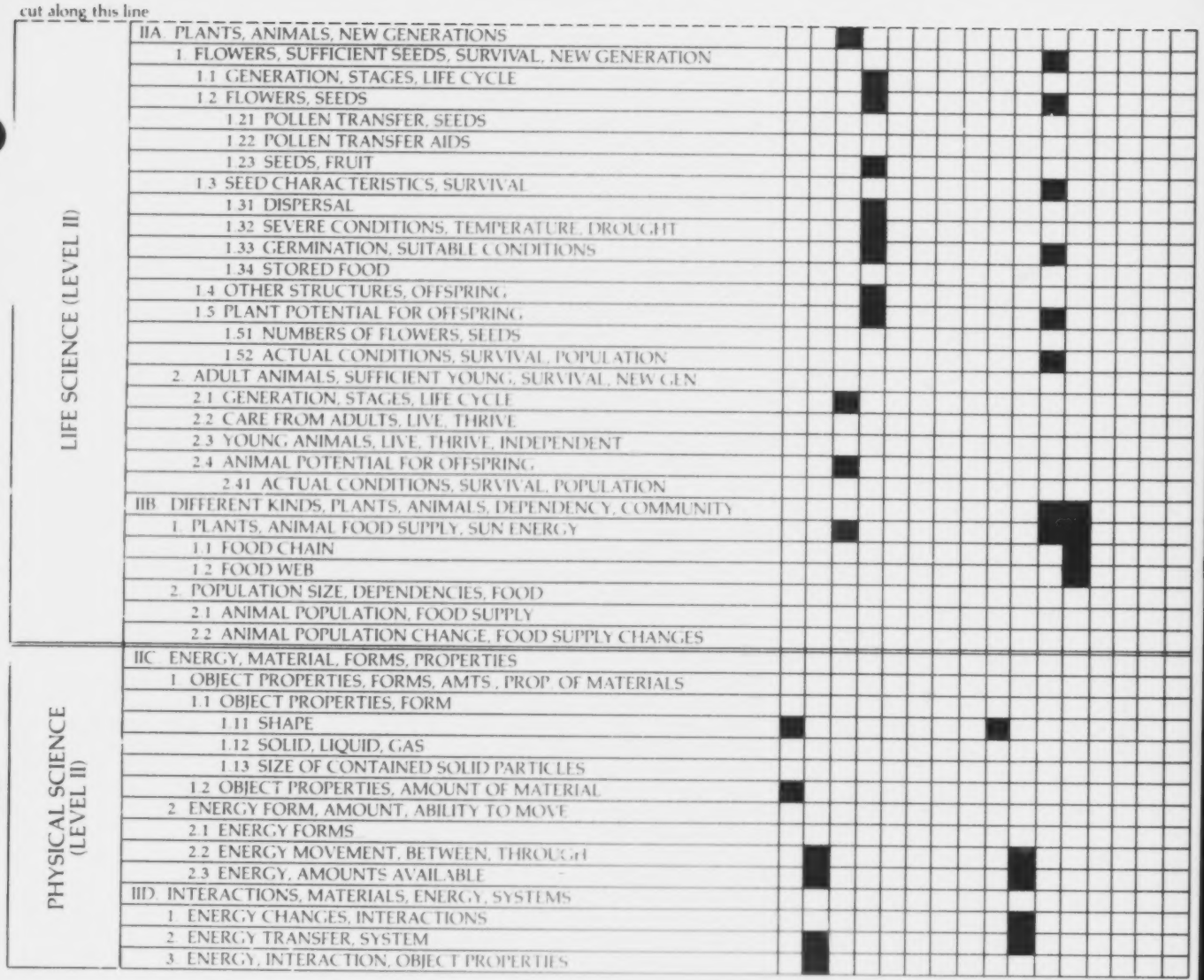
LIFE SCIENCE (LEVEL II)
PHYSICAL SCIENCE (LEVEL II)
IIA. PLANTS, ANIMALS, NEW GENERATIONS
1. FLOWERS, SUFFICIENT SEEDS, SURVIVAL, NEW GENERATION
1.1 GENERATION, STAGES, LIFE CYCLE
1.2 FLOWERS, SEEDS
1.21 POLLEN TRANSFER, SEEDS
1.22 POLLEN TRANSFER AIDS
1.23 SEEDS, FRUIT
1.3 SEED CHARACTERISTICS, SURVIVAL
1.31 DISPERSAL
1.32 SEVERE CONDITIONS, TEMPERATURE, DROUGHT
1.33 GERMINATION, SUITABLE CONDITIONS
1.34 STORED FOOD
1.4 OTHER STRUCTURES, OFFSPRING
1.5 PLANT POTENTIAL FOR OFFSPRING
1.51 NUMBERS OF FLOWERS, SEEDS
1.52 ACTUAL CONDITIONS, SURVIVAL, POPULATION
2. ADULT ANIMALS, SUFFICIENT YOUNG, SURVIVAL, NEW GEN
2.1 GENERATION, STAGES, LIFE CYCLE
2.2 CARE FROM ADULTS, LIVE, THRIVE
2.3 YOUNG ANIMALS, LIVE, THRIVE, INDEPENDENT
2.4 ANIMAL POTENTIAL FOR OFFSPRING
2.41 ACTUAL CONDITIONS, SURVIVAL, POPULATION
IIB. DIFFERENT KINDS, PLANTS, ANIMALS, DEPENDENCY, COMMUNITY
1. PLANTS, ANIMAL FOOD SUPPLY, SUN ENERGY
1.1 FOOD CHAIN
1.2 FOOD WEB
2. POPULATION SIZE, DEPENDENCIES, FOOD
2.1 ANIMAL POPULATION, FOOD SUPPLY
2.2 ANIMAL POPULATION CHANGE, FOOD SUPPLY CHANGES
IIC. ENERGY, MATERIAL, FORMS, PROPERTIES
1. OBJECT PROPERTIES, FORMS, AMTS., PROP. OF MATERIALS
1.1 OBJECT PROPERTIES, FORM
1.11 SHAPE
1.12 SOLID, LIQUID, GAS
1.13 SIZE OF CONTAINED SOLID PARTICLES
1.2 OBJECT PROPERTIES, AMOUNT OF MATERIAL
2. ENERGY FORM, AMOUNT, ABILITY TO MOVE
2.1 ENERGY FORMS
2.2 ENERGY MOVEMENT, BETWEEN, THROUGH
2.3 ENERGY, AMOUNTS AVAILABLE
IID. INTERACTIONS, MATERIALS, ENERGY, SYSTEMS
1. ENERGY CHANGES, INTERACTIONS
2. ENERGY TRANSFER, SYSTEM
3. ENERGY, INTERACTION, OBJECT PROPERTIES

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SYLLABUS - PROGRAM CORRELATION CHART
LEVEL II – UNIT STARTERS

	ACTIVITIES	UNIT STARTERS																
		MIRROR	MAGNETS	KITCHEN APPLIANCES	FINGER THERMOMETERS	MAKING SOUNDS	ENERGY TRANSFER	RAINDROPS	ECHOS	NURTURING BIRDS	HONEY OR VINEGAR	FISH BEHAVIOR	WOOLY BEAR FORECASTERS	SPRING FLOWERS	NATURAL COMMUNITY	GALLS	FINDING EA... FORMS
	Time Emphasis (Days)																
INQUIRY SKILLS	CLASSIFYING														■		
	CREATING MODELS																
	FORMULATING HYPOTHESES																
	GENERALIZING				■	■						■		■			
	IDENTIFYING VARIABLES																
	INFERRING															■	■
	INTERPRETING DATA																
	MAKING DECISIONS									■							
	MANIPULATING MATERIALS						■										
	MEASURING																
	OBSERVING	■						■			■		■				
	PREDICTING		■						■								
	RECORDING DATA			■													
	REPLICATING																
	USING NUMBERS																
LANGUAGE ARTS SKILLS/ PROCESSES	CLASSIFYING		■			■								■			
	DEVELOPING VOCABULARY																
	MANIPULATING IDEAS																
	QUESTIONING	■			■		■	■	■		■					■	
	RECORDING DATA												■				■
	USING CUES																
	ACQUIRING INFORMATION														■		
	COMMUNICATING INFORMATION			■						■		■					●
SCIENCE ATTITUDES	A. APPRECIATING, ENJOYING, NATURE																
	1. UNDERSTANDING, NATURAL WORLD																
	1.1 APPRECIATING NATURAL WORLD																
	1.11 COMPLEXITY, DIVERSITY, INTRICACY, ETC		■					■									
	1.12 RESOURCE, HUMAN NEEDS													■			
	1.2 RESPECTING LIFE									■							
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	1.22 SOURCE FOR CONTINUATION																
	1.23 AGING PROCESS																
	1.3 WANTING TO KNOW, UNDERSTAND																
	1.31 CONCEPTS, TERMS, TECHNIQUES, ETC																
	1.32 ACCURATE INFORMATION								■								
	1.33 EXPLANATIONS, INTERPRETATIONS, PREDICTIONS					■										■	■
	2. INVESTIGATIVE METHODS, NATURAL WORLD																
	2.1 SKEPTICISM, INVESTIGATION, REASONING																
	2.11 UNCERTAINTY OF INFORMATION, VERIFICATION										■		■				
	2.12 AMBIGUITY, CONTRADICTION, TENTATIVENESS	■			■							■			■		
	2.13 ORIGINAL INSIGHT, INFERENCES, ETC						■										
	2.14 CAREFUL, SYSTEMATIC INVESTIGATION																
	2.15 LOGICAL REASONING, VALIDITY OF IDEAS																
	2.2 RESPECTING OTHERS, ENVIRONMENT																
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	2.22 USE OF RESOURCES																
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	2.24 CONTRIBUTIONS, OTHERS																
	2.25 TRUTHFUL REPORTING																
	2.26 BELIEFS AND VALUES OF OTHERS																
	B. VALUING USE OF KNOWLEDGE FOR SOCIETY																
	1. THE PRACTICAL, TECHNICAL																
	1.1 SCIENTIFIC TECHNIQUES, MATERIALS																●
	1.2 RESOURCEFULNESS, INNOVATIVENESS																
	1.3 TECHNIQUE EFFICIENCY, SIMPLICITY, ETC																
	2. SERVICE THROUGH TECHNOLOGY																
	2.1 NEEDS, PROBLEMS OF OTHERS																
	2.2 BENEFITS OF TECHNOLOGICAL CHANGE			■													
	2.3 POTENTIAL ADVERSE CONSEQUENCES																

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LIFE SCIENCE (LEVEL II)	IIA. PLANTS, ANIMALS, NEW GENERATIONS	
	1. FLOWERS, SUFFICIENT SEEDS, SURVIVAL, NEW GENERATION	
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	1.5 PLANT POTENTIAL FOR OFFSPRING	
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	2.2 CARE FROM ADULTS, LIVE, THRIVE	
	2.3 YOUNG ANIMALS, LIVE, THRIVE, INDEPENDENT	
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	1. PLANTS, ANIMAL FOOD SUPPLY, SUN ENERGY	
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	1.2 FOOD WEB	
	2. POPULATION SIZE, DEPENDENCIES, FOOD	
	2.1 ANIMAL POPULATION, FOOD SUPPLY	
	2.2 ANIMAL POPULATION CHANGE, FOOD SUPPLY CHANGES	
PHYSICAL SCIENCE (LEVEL II)	IIC. ENERGY, MATERIAL, FORMS, PROPERTIES	
	1. OBJECT PROPERTIES, FORMS, AMTS., PROP. OF MATERIALS	
	1.1 OBJECT PROPERTIES, FORM	
	1.11 SHAPE	
	1.12 SOLID, LIQUID, GAS	
	1.13 SIZE OF CONTAINED SOLID PARTICLES	
	1.2 OBJECT PROPERTIES, AMOUNT OF MATERIAL	
	2. ENERGY FORM, AMOUNT, ABILITY TO MOVE	
	2.1 ENERGY FORMS	
	2.2 ENERGY MOVEMENT, BETWEEN, THROUGH	
	2.3 ENERGY, AMOUNTS AVAILABLE	
	IID. INTERACTIONS, MATERIALS, ENERGY, SYSTEMS	
	1. ENERGY CHANGES, INTERACTIONS	
	2. ENERGY TRANSFER, SYSTEM	
	3. ENERGY, INTERACTION, OBJECT PROPERTIES	

Schodack Central School District

II	BUOYANCY	

BUOYANCY

LEVEL II _____ (GRADE)

PROBLEM OVERVIEW

How can an object which sinks in water be made to float by itself? This problem underlies the successful operation of all boats made of materials that do not normally float. Solving the problem involves investigating shapes of objects and the effect shapes have on the buoyancy of an object. Which boat shape is the best?

SUGGESTED SCHEDULE/SYLLABUS EMPHASIS

#	Activity Title	Week 1	Week 2	Week 3	Emphasis
1	Sink or Float				Creating Models/Communicating Information B-1.2 Resourcefulness, innovativeness II-C-1.11 Shape
2	Boat Shapes				Inferring/Classifying A-2.23 Contributing fair share of effort II-C-1 Objects, properties, forms, amounts, properties of materials
3	Stability				Making Decisions/Questioning A-2.15 Logical reasoning, validity of ideas II-C-1.11 Shape
4	Capacity				Predicting/Communicating Information A-2.24 Contributions, others II-C-1.11 Shape
5	Different Materials				Identifying Variables/Communicating Information A-2.26 Beliefs and values of others II-C-1.11 Shape
6	Floating on Salt Water				Formulating Hypotheses/Questioning A-2.11 Uncertainty of information, verification II-C-1.2 Object properties, amount of material
7	Displacement				Creating Models/Communicating Information A-2.23 Contributing fair share of effort II-C-1.2 Object properties, amount of material

SUGGESTED APPROACH

Students are given an opportunity to solve a problem by altering a piece of clay to make it float. After carefully observing shapes of real boats, students test models in an attempt to find which ones are most stable and have the greatest load-carrying capacity. The interaction between a boat and water which results in buoyancy is also observed.

Many of the activities in this unit have a connection to other subjects such as mathematics, social studies, and art. Outcomes for those subjects may also be developed through these activities.

MATERIALS

(per student)

Plasticine – two strips
Container, clear plastic (two-liter)
Paper towels
Pennies
Paper clips
Thumbtacks
Ceramic weights
Plastic cup, 2 oz.
Aluminum foil
(heavy duty), 15 cm x 15 cm

(per pair)
Salt, 1 cup

(per class)
Double pan balance

MORE IDEAS

1. Boat Olympics

Have students construct boats at home as a culminating activity. Write a paragraph describing: materials used, construction of boats, purpose or use of boat, description and special features of boat, name of boat and why that name was chosen. Obtain a large plastic wading pool for testing the boats and experimenting with large loads.

2. Build a boat that "floats" underwater, simulating a submarine.

3. Write stories and poems about boats.

4. Read stories and poems about boats.

5. Invite a representative from the Navy, the Coast Guard, or the Power Squadron to discuss boats, buoyancy, and boat safety.

6. Take students to a nearby port and have the captain of a boat/ship explain the capacity of the vessel and its relationship to buoyancy.

7. Have students investigate (in the library) the concept of buoyancy in whales and report to the rest of the class.

8. Research types of boats used in various countries from past to present. Identify shapes, purposes, and sizes. Make scale models for display.

SYLLABUS EMPHASIS	ACTIVITIES	SUPPLEMENTARY INFORMATION

Problem:

How can an object which sinks be made to float by itself?

Concepts:

buoyancy
float
shape
sink

Skills Processes	**Inquiry:** Creating Models • Making sketches of a plasticine shape that can float. **Language Arts:** Communicating Information • Prewriting that focuses the student on the science content of sinking and floating.
Science Attitudes	B-1.2 Valuing resourcefulness and innovativeness in the solution of practical problems. • Attempting to use materials in novel ways to solve problems.
Science Understandings	II-C-1.11 Properties of an object can be affected by the shape of the material. • Buoyancy of plasticine can be affected by its shape.

Evaluation Strategy:

Individual

Students are able to construct a plasticine model that floats.

1. SINK OR FLOAT

Roll one strip of plasticine into a ball. Ask students to predict what will happen to the ball of plasticine when it is placed in water. Place the ball of plasticine in a transparent demonstration container of water. Students will observe that the ball of plasticine sinks.

Class Discussion:

Why did the ball of plasticine sink? How can you make a ball of plasticine float?

Distribute materials to each student. Encourage students to experiment with different shapes in order to get their shape to float. Have students draw rough sketches of those shapes that floated and those that did not.

Ask students what they did to make their plasticine float. Which shapes floated? Which shapes sank?

Ask students to brainstorm words that come to mind when you say "sink" and "float". List the words on chart paper or on a chalkboard. Have the group use as many of the words as they can to construct a story about making the plasticine float.

Materials:

For teacher demonstration:

Two-liter transparent container partially filled with water
One strip of plasticine

For each student:

Two-liter container:
One strip of plasticine
Water
Paper towels
Paper and pencil

For the class:

Double pan balance

Procedural Notes:

1) Use room-temperature water when doing experiments to keep plasticine from flaking.

2) After activity, clay should be reshaped into balls and stored in an open container that permits clay to dry.

3) The scale can be used to show that the ball of clay weighs the same as the shape that floated.

SYLLABUS EMPHASIS	ACTIVITIES	SUPPLEMENTARY INFORMATION

Problem:

In what shapes are boats made?

Concepts:

boat
buoyancy
groups
shape

Skills/Processes	**Inquiry:** Inferring • Students draw inferences about groups of boats from available evidence. **Language Arts:** Classifying • Pictures of boat shapes are grouped according to similarities.	
Science Attitudes	A-2.23	Valuing the contribution of a fair share of the effort in carrying out collaborative studies.
	• Students share in the effort to create collages.	
Science Understandings	II-C-1	Objects have properties determined by the forms, amounts, and properties of the materials of which they are made.
	• Boats with unique shapes or forms are identified.	

Evaluation Strategy:

Individual

Students are able to group pictures of boats into categories according to shape.

2. BOAT SHAPES

Ask students how they might find out what are the common shapes of boats. List ideas they suggest. Help them devise a plan for solving their problem. What materials or resources will be needed? Where can the resources be found? Provide access to library books. Encourage students to bring in old or discarded catalogs, magazines, and photographs that show boats.

Allow students to cut pictures from discarded resources or to draw replications of boat shapes from other resources.

Ask students to group the pictures according to shapes. Students can form groups to prepare a collage of pictures for each representative shape. The collages can become a bulletin board display for reference during the remaining activities of the unit.

Class Discussion:

How many different groups of boat shapes were found?

Which group (groups) seems to be used most for carrying cargo?

Which group (groups) seems to be used most for carrying people?

Which group (groups) seems to be the fastest?

Which group (groups) seems to be the prettiest? How can you decide what "prettiness" means?

What materials seem to be used to construct the various boats?

Explain why each boat shape is used the way it is.

Materials:

Library books about boats
Catalogs showing boats (from home)
Photos from magazines, etc. (from home)
Scissors
Tape
Construction paper

Safety Note:

Precautionary safety rules for using scissors should be reviewed.

Procedural Notes:

1) Students allowed to work in groups may need assistance in deciding how to assign tasks, assume leadership roles, and cooperate to accomplish an objective.

2) Time should be taken to explore these factors as the need arises.

SYLLABUS EMPHASIS	ACTIVITIES	SUPPLEMENTARY INFORMATION

Problem:

How does the shape of a boat affect its stability?

Concepts:

buoyancy
float
sink
stability

Skills Processes	**Inquiry:** Making Decisions • Rules are needed as standards to guide in making decisions. **Language Arts:** Questioning • Questions, carefully planned, will help guide investigations.
Science Attitudes	A-2.15 Valuing logical reasoning as a means of testing and weighing the validity of ideas. • Using logic to develop rules for deciding on boat stability.
Science Understandings	II-C-1.11 Properties of an object can be affected by the shape of the material. • Varying the shape of a plasticine boat will affect its stability.

Evaluation Strategy:

Individual

Students will be able to construct a statement to describe the effect of a boat's shape on its stability.

3. STABILITY

Students construct plasticine boats of different shapes, similar to the general shapes identified in Activity 2. The students should discuss their ideas about what stability means. These ideas might be recorded on the board.

A variety of questions will help guide their investigation of the problem. These might include:

- Does a boat remain stable as different loads are used?
- Does the placement of a load affect a boat's stability?
- When is a boat stable?
- How would you decide when a boat is stable?
- What could be done to a given boat's shape to increase its stability?

The students should construct "Rules for Deciding" to help guide them in judging a given boat's stability. The rules might take this form: "A boat is stable if . . . ."

Class Discussion:

How does the shape of a boat affect its stability?

Continue with a general discussion of students' observations and the conclusions made during their experimentation.

A sampling of different results might be recorded or charted on the chalkboard.

After discussion, have students write a concluding statement on the effect boat shapes have on stability.

Materials:

For each pair of students:

Two-liter container – 1
Plasticine ball (for each boat type)
Towels
Variety of small, uniform objects to be used as test cargo (ceramic weights, pennies, paper clips, thumbtacks, etc.)

Procedural Notes:

1) Students should have equal amounts of plasticine to make each boat shape. The double pan balance may be used to settle disputes concerning amounts of plasticine.

2) Students should try to keep their boats dry, using paper towels after testing.

3) Save students' boats for the next activity.

SYLLABUS EMPHASIS	ACTIVITIES	SUPPLEMENTARY INFORMATION

Problem:

How does the shape of a boat affect its capacity?

Concepts:

buoyancy
capacity
cargo
float
load
sink
space
weight

Skills/Processes	**Inquiry:** Predicting • Students predict how many objects can be added to a boat before the boat sinks. **Language Arts:** Communicating Information • Information gathered and interpreted can be summarized in the form of a statement.
Science Attitudes	A-2.24 Respecting the contributions of others to the solution of a problem. • Sharing and respecting one another's efforts as boats are shaped and tested.
Science Understandings	II-C-1.11 Properties of an object can be affected by the shape of the material. • Varying the shape of a plasticine boat will affect its capacity or buoyancy.

Evaluation Strategy:

Group

Students will be able to construct a statement that describes the effect of a boat's shape on its load capacity.

4. CAPACITY

Students use plasticine to construct different-shaped boats that can hold cargo. The students share a variety of small objects designated for use as cargo. Students predict how many objects of the same kind can be floated in each type of boat. Predictions and actual capacity are recorded by each student.

Some thought questions such as those listed below might be suggested during this experimentation time.

Class Discussion:

How does the shape of a boat affect its capacity?

Does the placement of the cargo affect your boat's capacity?

Continue with a general discussion of observations and possible conclusions students made during the experimentation.

A sampling of different results might be recorded or graphed on the chalkboard.

After discussion, have students write a concluding statement on the effect boat shapes have on capacity.

Materials:

For each pair of students:

Two-liter container – 1
Plasticine boats from previous activity
Towels
A variety of small, uniform objects to be used as cargo (pennies, paper clips, thumbtacks, ceramic weights, etc.)

Procedural Notes:

1) Students' boats should have been made from equal amounts of plasticine. The double pan balance may be used to settle disputes concerning amounts of plasticine.

2) Students, using paper towels, should try to keep their boats and cargo dry after testing.

3) Each type of object used as cargo should be the same size and weight.

SYLLABUS EMPHASIS	ACTIVITIES	SUPPLEMENTARY INFORMATION

Problem:

Which materials make better boats?

Concepts:

capacity material
float sink

Skills/Processes	**Inquiry:** Identifying Variables • Students will identify variables to be considered in comparing aluminum foil and plasticine. **Language Arts:** Communicating Information • Students will participate in brainstorming or hypothesizing as a prelude to an investigation.
Science Attitudes	A-2.26 Respecting the beliefs and values of others in presenting one's own ideas or findings. • Discussion of experimental results provides opportunity to respond to the ideas of others.
Science Understandings	II-C-1.11 Properties of an object can be affected by the shape of the material. • Students will check the buoyancy of aluminum foil shaped like a boat and its structural strength when ceramic sinkers are used to test its capacity.

Evaluation Strategy:

Group

Students will be able to identify advantages and disadvantages of different materials for boats.

5. DIFFERENT MATERIALS

Ask students to suggest how to solve the problem if the materials are aluminum foil and plasticine.

Introduce aluminum foil as a boat building material different from plasticine.

Distribute one piece of aluminum foil (15 cm x 15 cm) to each student.

Develop several suggested procedures through group discussion. Allow time for building and testing.

Class Discussion:

How did you make the aluminum foil float?

What ideas did you use to make your boat structurally sound?

Did your boat have sides?

What ideas worked better than others?

Did any ideas not work? Which ones? What happened?

Have students predict how many ceramic weights their aluminum foil boats will hold. Have students find the capacity of their aluminum boats and record results.

A general discussion should follow in which students discuss the advantages and disadvantages of aluminum foil boats as compared to plasticine boats.

Materials:

Container (two-liter)
Water
Paper towels
Aluminum foil (heavy duty)
Ceramic weights
Results from Activities 3 and 4
Pencil/paper

Procedural Note:

Precut a foil square 15 cm x 15 cm for each student.

SYLLABUS EMPHASIS	ACTIVITIES	SUPPLEMENTARY INFORMATION

Problem:

What effect does salt water have on a boat's buoyancy?

Concepts:

buoyancy
density
float
sink

Skills/Processes	**Inquiry:** Formulating Hypotheses • "If-then" statements can be written to describe preconceptions about buoyancy in salt water. **Language Arts:** Questioning • Students are stimulated to think of questions which, when answered, will help solve a problem.
Science Attitudes	A-2.11 Accepting information and ideas about the natural world as uncertain and valuing verification and supporting reasons. • Testing claims about changes in a boat's buoyancy in salt water through observation and experimentation.
Science Understandings	II-C-1.2 Some properties of an object may be determined by the amount of material in the object. • Properties of water are affected by dissolved substances.

Evaluation Strategy:

Individual

Students are able to describe the effect of salt water on a boat's buoyancy.

6. FLOATING ON SALT WATER

Ask students what effect salt water might have on buoyancy. Develop their hypotheses through discussion. Write these hypotheses on the chalkboard. Students should brainstorm questions they need to answer in order to test each hypothesis. For this activity a uniform-sized plastic cup is used as a "standard boat". Help develop a rationale for use of a standard boat to limit the variables.

Provide each pair of students with 2 two-liter containers, each filled with about one liter of warm water. The students should add one cup of salt to one container and stir (salt takes time to dissolve).

Students find out how many ceramic weights their "standard boat" can hold in unsalted water and record results.

Students find out how many ceramic weights their "standard boat" can hold in salted water and record results. Students share results with the class.

Class Discussion:

Did the "standard boats" hold more cargo when floating on salted or unsalted water? What might be the best explanation for the observation?

Materials:

For each pair of students:

Two-liter containers – 2, each filled with 1 liter of warm water
Salt, 1 cup
Ceramic weights
Plastic medicine cup – 2 oz. size – 1
Spoon or stirrer
Pencil/paper

Procedural Notes:

1) Water needs to be warm enough to dissolve salt but not hot enough to harm students.

2) Cups and ceramic weights need to be dried between tests.

SYLLABUS EMPHASIS	ACTIVITIES	SUPPLEMENTARY INFORMATION

Problem:

What happens to the water in a lake when a boat gets heavier?

Concepts:

buoyancy
displacement
level
weight

Skills/Processes	**Inquiry:** Creating Models • A graph can be produced to show effect of boat load on water level. **Language Arts:** Communicating Information • Verbal descriptions of observations and conclusions are shared.
Science Attitudes	A-2.23 Valuing the contribution of a fair share of the effort in carrying out collaborative studies. • Doing one's share of work in a group project.
Science Understandings	II-C-1.2 Some properties of an object may be determined by the amount of material in the object. • Amount of water a plastic cup boat will displace.

Evaluation Strategy:

Group

Student will be able to describe conclusions about what happens to the water level as a boat's load is increased.

7. DISPLACEMENT OF WATER

Ask the students what they think happens to the water as a boat's load increases. Help students develop hypotheses and questions needed to solve the problem.

Students should test their hypotheses by gradually increasing the weight of their standard boat by adding ceramic weights. The resulting level of water can be marked directly on the piece of tape on the side of the container as shown in the diagram. Using the tape marks, students may want to make a graph that shows the new water level on the vertical axis and the boat weight on the horizontal axis. Boats can be weighed each time if students want to make their measurements more quantified.

Class Discussion:

What happened to the water level as the boat got heavier?

How would the effect change if the lake were larger, smaller, or deeper?

What are some practical examples in which this effect is important?

Materials:

Double pan balance

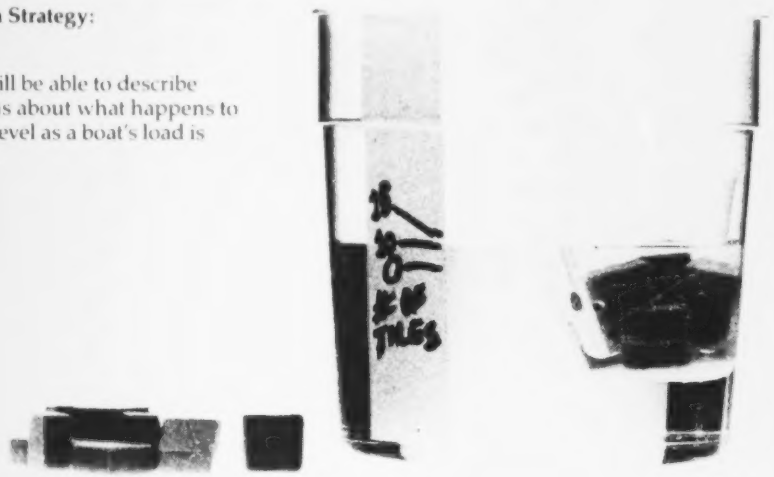
For each pair of students:

Container (two liter)
Plastic cups, 2 oz. size – 2
Plastic straw, 1
Ceramic weights
Water
Paper towels
Masking tape

Procedural Notes:

1) Students may discover that a greater change in water level can be produced by using more than one boat in a given tank.

2) This activity will provide an opportunity to develop graphic skills for mathematics.



II	BULBS, BATTERIES, AND WIRES	

BULBS, BATTERIES, AND WIRES

LEVEL II _____ (GRADE)

PROBLEM OVERVIEW

What would happen if a bulb, a battery, and wire were connected? The Level II-age child who is familiar with flashlights, toys, and other gadgets containing bulbs can probably give the correct answer to this question: you should be able to light the bulb.

There are other questions, however, that children of this age group cannot answer. For example, are all D batteries the same? Each of these questions can serve as a subproblem of the larger problem, "How does electricity move from one object to another and through different materials?". This question is investigated in this unit.

SUGGESTED SCHEDULE/SYLLABUS EMPHASIS

#	Activity Title	Week 1	Week 2	Week 3	Week 4	Week 5	Emphasis
1	Bulb, Battery, and Wire						Manipulating Materials/Questioning A-2.25 Truthful reporting II-D-3 Energy, interaction, object properties
2	Measuring Bulb Brightness						Making Decisions/Communicating Information A-2.14 Careful, systematic investigation II-C-2.2 Energy movement, between, through
3	Battery Durability						Identifying Variables/Communicating Information A-2.1 Skepticism, investigation, reasoning II-C-2.2 Energy movement, between, through
4	Wires						Predicting/Communicating Information A-1.31 Concepts, terms, techniques, etc. II-C-2.2 Energy movement, between, through
5	Bulbs						Inferring/Communicating Information A-1.33 Explanations, interpretations, predictions II-D-3 Energy, interaction, object properties
6	Constructing a Bulb						Formulating Hypotheses/Communicating Information A-2.21 Safety II-D-3 Energy, interaction, object properties
7	Making a Fuse						Manipulating Materials/Acquiring Information A-1.31 Concepts, terms, techniques, etc. II-D-3 Energy, interaction, object properties
8	Solid Conductors and Nonconductors						Observing/Developing Vocabulary A-2.11 Uncertainty of information, verification II-C-2.2 Energy movement, between, through
9	Liquid Conductors and Nonconductors						Observing/Communicating Information A-2.11 Uncertainty of information, verification II-C-2.2 Energy movement, between, through
10	Electrical Devices – Insulated Wire						Creating Models/Communicating Information B-1.2 Resourcefulness, innovativeness II-C-2.2 Energy movement, between, through
11	Electrical Devices – Switches						Creating Models/Recording Data B-1.3 Technique efficiency, simplicity, etc. II-D-2 Energy transfer, system

SUGGESTED APPROACH

This unit is intended to be conducted at an introductory level. This may be the first time students have classroom experiences using batteries and bulbs to produce current electricity. This unit will provide an important base of experiences and understandings for later experiences involving electrical systems and (in Level III) with electrical circuits and energy transfer. Many opportunities will occur throughout the unit to deal with science attitudes relating to safety and investigational procedures. Many skills, especially those related to decision making, can be further developed.

As students try to unravel the problems with bulbs, batteries, and wires, understandings gained in Level I relating to properties of objects and events can be reinforced.

It may be useful for each group of two students to have a small box, such as a shoe box, to store materials. The box can be used throughout the unit to keep each group's batteries, bulbs, wires, Fahnestock clips, and battery holders together for daily activities.

Before beginning each activity, you may want to devise a battery tester from a bulb and some wire to make sure the batteries are working.

MATERIALS

Shoe boxes (cardboard) – 1 per pair of students
Liquid soap – 1 bottle
Solids – scissors, erasers, pencils, string, meter stick, etc.
Chart paper
Centimeter rulers
Milk cartons
Plasticine – 1 pound
Plastic drinking straws – 30
Screwdriver – 1
#41 bulbs – 100
#48 bulbs – 100
Small diameter solder – 1 small coil
Fahnestock clips – 200
Cleansing powder – 1 can
Wire strippers – 10
#32 nichrome wire – 1 spool
#20 bare copper wire – 1 spool
#24 plastic insulated copper wire – 100 pieces, 30 cm each
Open bulb holders – 60
Plastic tumblers – 15
Paper fasteners – 1 box
Paper clips (#1) – 1 box
Cooking oil – 1 bottle
Vinegar – 1 bottle
Salt – 10-12 cups
D batteries – 72 carbon type
C batteries – 6 carbon type
AA batteries – 6 carbon type
AAA batteries – 6 carbon type
Dry cell battery – 1 carbon type

MORE IDEAS

1. Describe how a flashlight is like a battery- bulb-and-wire combination and how it is different from the combination. Draw a diagram showing how electricity moves through the flashlight.

2. Test several brands of D cells to determine which is most durable.

3. Take a household bulb apart. Put a bulb into a paper bag and gently tap it with a hammer. Compare the structure of the household bulb with either a #48 bulb or a #41 bulb.

4. Investigate the effect of several bulbs on battery durability. How long will a battery keep several bulbs lighted? Connect two, three, four, or more bulbs, and measure the resultant durability of a given battery (D cell).

5. Create a bulletin board display featuring analogies such as: "A switch is to electricity as _____ is to _____".

To complete the blanks, these terms could be used:

– a faucet, water
– an earplug, sound
– a window shade, sunlight
– photochrome glass, sunlight
– a traffic light, traffic
– a railroad switch, rail traffic

SYLLABUS EMPHASIS	ACTIVITIES	SUPPLEMENTARY INFORMATION

Problem:

What would happen if a bulb, a battery, and a wire were connected?

Concepts:

connect	prediction
electricity	report
energy	system
interaction	terminal

Skills Processes	**Inquiry:** Manipulating Materials • Students manipulate a bulb, a battery, and a wire to light the bulb. **Language Arts:** Questioning • Students identify and state questions for further study.
Science Attitudes	A-2.25 Valuing truthful reporting of methods and findings. • Considering and appreciating the consequences of accurately reporting findings.
Science Understandings	II-D-3 When energy interacts with objects in a system, the properties of the objects may be changed. • Electricity flowing in a wire causes the wire to become warm and glow.

Evaluation Strategy:

Group

Students are able to draw pictures showing combinations of a bulb, a battery, and a wire that would light a bulb, and they are able to connect a bulb, a battery, and a wire to light a bulb.

1. BULB, BATTERY, AND WIRE

Show students a bulb, a battery, and a piece of wire. Raise the problem question. Ask the students to use their prior knowledge to predict what would happen. Some may think the wire wouldn't be needed, while others may think two wires would be needed. Still others may think the bulb will light when it touches the end of the battery. Write students' predictions on the chalkboard or chart paper. Provide pairs of students with a bulb, a battery, and a piece of wire, and ask them to test all the predictions just made. Find out which predictions were true.

Ask students to draw pictures showing how they connected the bulb, battery, and wire to make the bulb light. Compare all of the drawings.

Class Discussion:

How many different types of drawings were made? (You'll find that many children will have forgotten some of their work because they did not keep a record of it. This realization should enable them to see the need for keeping simple notes and diagrams.)

What other ways might the bulb, battery, and wire be connected to make the bulb light? (If all possible ways were found as students tested their predictions, this question need not be asked.)

Where must the battery be touched to make the bulb light?

Where must the bulb be touched to make it light?

Is the wire needed to make the bulb light?

Ask the students to think about other questions they might try to answer with new investigations into bulbs, batteries, and wires. Some examples might include:

Are all batteries the same? Are some better than others? Why are some batteries different? Are all bulbs the same? Could different wires make the bulb light? Brainstorm a list of these questions, which should be written on chart paper and kept for the rest of the unit.

Materials:

For each pair of students:

Chart paper
D cell – 1
#48 bulb – 1
#20 bare copper wire, 20 cm piece – 1
Notebook paper for diagram

Safety Notes:

1) Caution students always to make sure their hands are dry when working with electrical devices.

2) Always check for corroded or leaking batteries before you begin each activity. Dry cells contain no acid, but they do contain corrosive chemicals in a wet paste. Corroded or leaking cells should be disposed of immediately. These should not be placed in trash that will be burned. Any damaged cells discovered by students should be given to the teacher for proper disposal.

Procedural Notes:

1) A battery is a connected group of cells storing energy and capable of producing an electrical current. The cylinder commonly called a battery is actually a cell. However, throughout this unit these cells will be called by the common name, battery.

2) Terminals are the places on the battery and bulb that, when touched, allow the electricity out of or into the device.

3) The positive terminal of a battery is the raised terminal in the center of one end.

SYLLABUS EMPHASIS	ACTIVITIES	SUPPLEMENTARY INFORMATION

Problem:

How bright is a bulb?

Concepts:

absorb
brightness measure
complementary
rules
thickness

Skills/Processes	**Inquiry:** Making Decisions • Setting rules for deciding how to measure the brightness of a bulb. **Language Arts:** Communicating Information • Students discuss and establish rules for making decisions.
Science Attitudes	A-2.14 Valuing careful, systematic investigation as useful in resolving issues. • Consequences are considered and appreciated for systematic investigation.
Science Understandings	II-C-2.2 Energy can move from one object to another, through materials and through space. • Students use the effects of different thicknesses of paper to measure bulb brightness.

Evaluation Strategy:

Group

Students will be able to state decision-making rules for use of a brightness measurer and will be able to use the measurer to determine the brightness of different bulbs.

2. MEASURING BULB BRIGHTNESS

Ask students to brainstorm how they might measure the brightness of a lighted bulb. Record all of their suggestions on the board or on chart paper. Discuss advantages and disadvantages of each method. Indicate to them that in this unit a simple brightness measurer will be used to help decide on the brightness of a lighted bulb.

Show students a completed brightness measurer and briefly use it to demonstrate the measurement with a lighted bulb.

Provide students with the materials needed to construct their brightness measurers.

After each shape is cut out, number each piece as shown in the photograph below. The complete circle is numbered 1 and the smallest section is numbered 10. Staple or tape the sections together with the complete circle on the bottom. The smallest section should be on top.

Class Discussion:

What causes different measurements to occur for the same brightness?

How can the measurer be used to obtain the same results?

What decision-making rules are needed to decide upon the brightness of a bulb when the measurer is used?

What safety rules must be followed when using the measurer?

Which bulb is brightest?

Materials:

For each student:

Sheet containing section shapes – 1
Scissors – 1

For each group of four students:

#41 bulb – 1
#48 bulb – 1
Bulb holder – 2
D cell with holder – 1
#20 bare copper wire, 20 cm piece – 2

For the class:

Paper staples or transparent tape

Procedural Notes:

1) If students suggest an approach that uses a measuring device similar to the brightness meter used here, use that opportunity to begin construction of the meter.

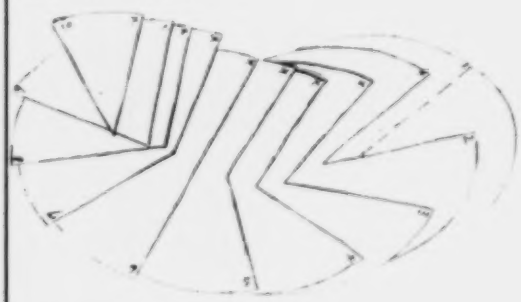
2) Note that a circle cut to produce one shape also produces the complementary shape. This observation can be related to math.

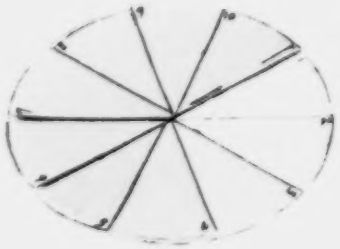
3) Different measurements of brightness will result from holding the measurer at different distances from the lighted bulb. Differences in batteries or bulbs will also produce different measurements.

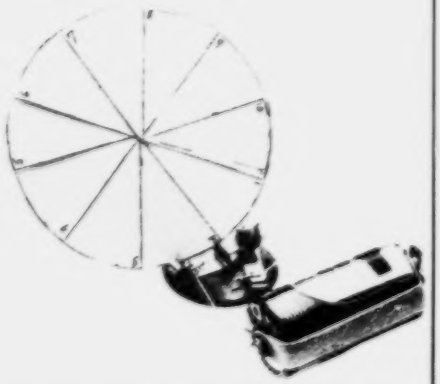
4) A battery holder with connecting clips can be constructed to simplify making connections to the battery. Instructions at the end of the unit can be used if you wish to have students construct the holder.

Safety Note:

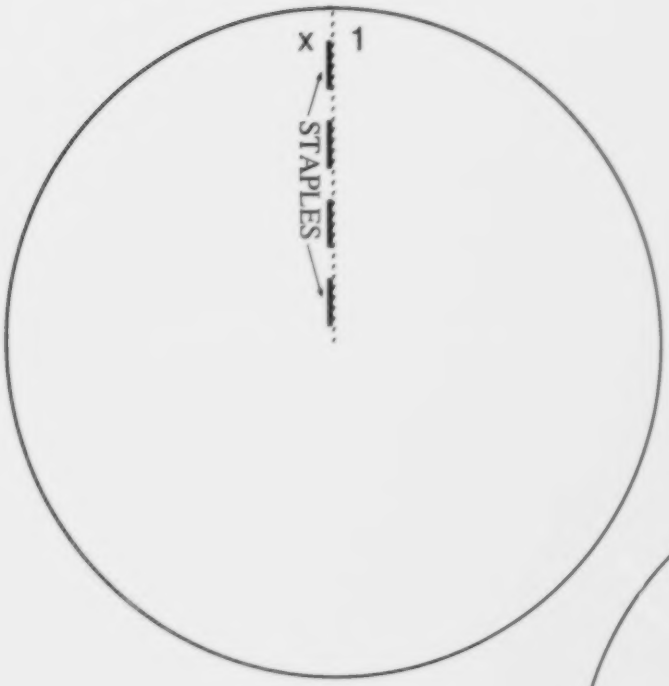
Discuss safety rules for using the measurer. Why can't it be used to measure brightness of a flame? Why can't it be used to measure the brightness of the sun?

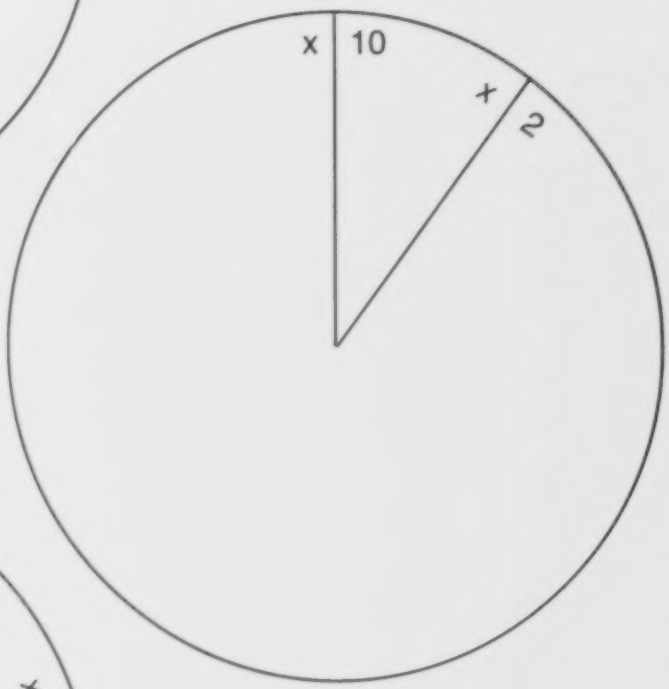


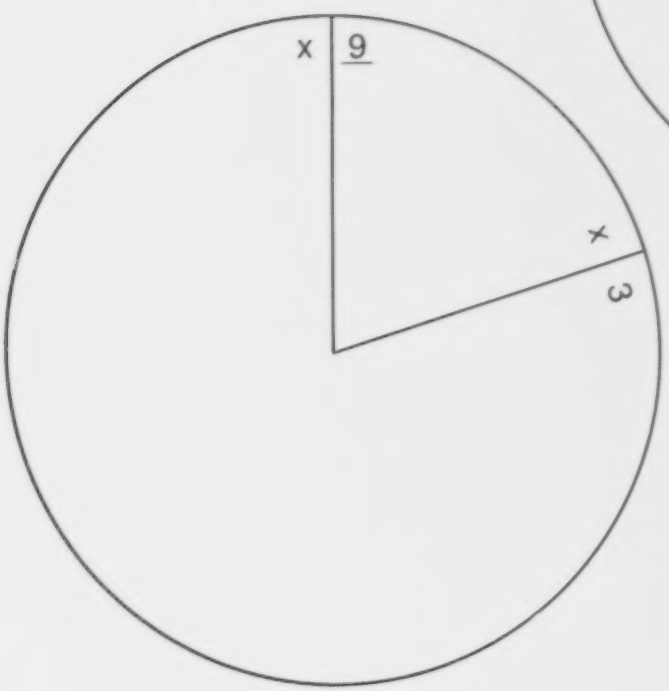




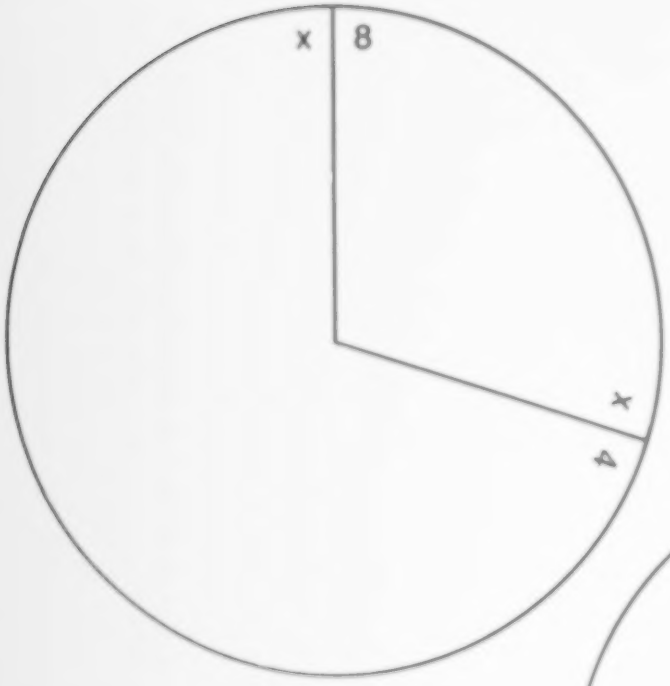
BRIGHTNESS TESTER

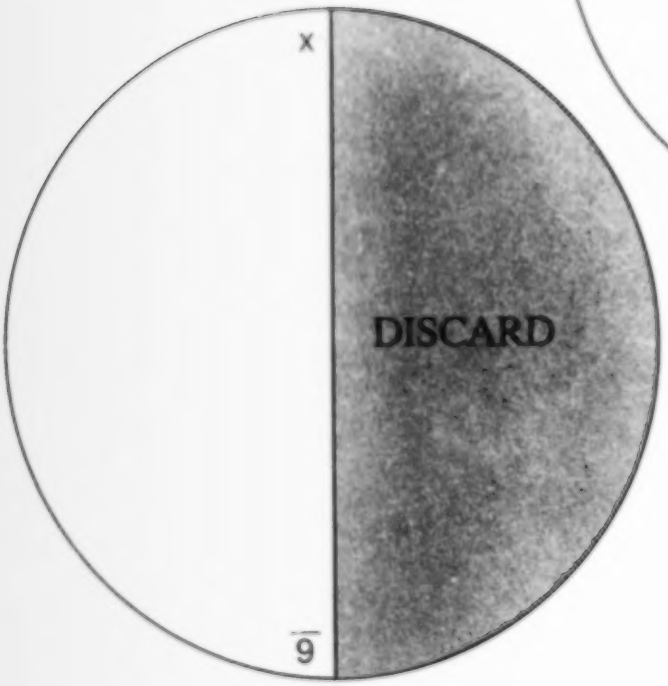






BRIGHTNESS TESTER





3.

SYLLABUS EMPHASIS	ACTIVITIES	SUPPLEMENTARY INFORMATION

Problem:

Which battery is most durable?

Concepts:

consumer
discrepancy
durability
duration
energy

Skills Processes	**Inquiry:** Identifying Variables • Factors which affect the measurement of battery durability are identified. **Language Arts:** Communicating Information • Students summarize and share data obtained through investigation.
Science Attitudes	A-2.1 Valuing skepticism, careful investigation, and logical reasoning as means of increasing one's understanding of the natural world. • Considering the value of logical reasoning and systematic investigation to resolve the issue of battery durability.
Science Understandings	II-C-2.3 The amount of energy available from a source can vary. • The amount of electrical energy in a particular battery affects the length of time a light bulb can be lighted.

3. BATTERY DURABILITY

Show students several different-sized carbon-type batteries (AA, AAA, C, D, dry cell).

Ask them to predict which will make a bulb (#41) light brightest. Ask them to explain how they arrived at their prediction.

Demonstrate each battery lighting a single #41 bulb. Have "student assistants" measure the brightness each time. Record the results on the board.

Materials:

Brightness measurer
D cell (battery holder)
Bulb holder
#41 bulb
#20 bare copper wire, 20 cm pieces – 2
White construction paper

For each group of four to five students:

#41 bulb – 1
Bulb holder – 1
#20 bare copper wire, 20 cm pieces – 2
Batteries (AAA, AA, C, D, and dry cell) – 1 each (assign one type to each group)

Procedural Notes:

1) If students doubt that each battery caused the bulb to glow the same brightness each time, connect all batteries to separate #41 bulbs at the same time.

If one battery size does cause the bulb to be brighter or dimmer than the other battery sizes, include that discrepancy in the durability test. Students may realize that all of the batteries are labeled 1.5 volts.

2) Decisions will have to be made for running the durability tests longer than the school day, or over a weekend, if necessary.

3) Groups might take turns using different batteries to make measurements to avoid the competition of one group "getting the best battery."

4) Graphs can be drawn on white construction paper. Draw axes in black (crayon or marker). Draw lines or bars with rainbow colors (colors of the spectrum).

More Ideas:

Numbers 2 and 4 may be interesting activities to extend the investigation, depending on student interest.

SYLLABUS EMPHASIS Cont'd	ACTIVITIES Cont'd	SUPPLEMENTARY INFORMATION Cont'd
	Discuss the discrepancy between the most common prediction and the actual results. (The smallest battery and the largest battery created an identical degree of brightness.)	
	Class Discussion:	
	How does the bulb brightness of the smallest battery compare to that of the largest battery?	
	What property might be different for the different-sized batteries?	
	What property might be different for the same-sized batteries? (Example: Are all D cells the same?)	
	How long will a battery keep a bulb lighted?	
	What procedure could be used to test the durability of batteries?	
	What properties are the same for the different-sized batteries?	
	Help students devise a group plan for the procedure they will use to test the durability of batteries.	
	Some of the questions that might be investigated could include:	
	• Are all brands of D cells the same?	
	• Are several different D cells of one brand the same?	
	• Are dry cells more durable than AAA cells?	
	• Will batteries recharge or "come back to life" after they are "run down"?	
	For comparison, results of the battery durability tests can be placed on a graph.	
Evaluation Strategy:		
Group		
Students will be able to describe a procedure for comparing the durability of different batteries.		

SYLLABUS EMPHASIS	ACTIVITIES	SUPPLEMENTARY INFORMATION

Problem:

Which wire conducts electricity best?

Concepts:

diameter	size
electricity	test (tester)
length	variable
resistance	

Skills Processes	**Inquiry:** Predicting • Students make simple predictions about an outcome. **Language Arts:** Communicating Information • Students summarize and share data obtained through investigation.
Science Attitudes	A-1.31 Wanting to know concepts, terms, techniques, and conventions useful in understanding the natural world. • Trying to learn how to use measuring instruments.
Science Understandings	II-C-2.2 Energy can move from one object to another through materials and through space. • Electricity moves more easily through some metals than through others.

Evaluation Strategy:

Group

Given a tester and wires of various lengths and thicknesses, the students will be able to identify which wire allows the greatest amount of electricity to flow.

4. WIRES

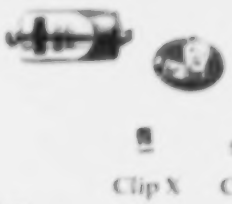
Show students several different wires including long, short, thick (large diameter), thin (small diameter) and different composition such as copper, nichrome, and iron (coat hanger). Ask students to predict which wire will conduct electricity best.

Ask the class to decide on procedures to test the wires. Record the information and then display or present it.

Students should begin with the #32 nichrome wire.

Have the students connect a 20 cm piece of the wire to Fahnestock clip Y.

Move Fahnestock clip X along the nichrome wire, while keeping the clip in constant contact with the nichrome wire.



Clip X Clip Y

Class Discussion:

What happens to the brightness of the bulb when Fahnestock clip X is moved along the nichrome wire away from Fahnestock clip Y?

What did moving clip X away from clip Y do to the length of the wire that was connected?

What part of the problem has been answered?

What do you think will happen if the #26 thick (large diameter) nichrome wire is substituted for the #32 thin (small diameter) nichrome wire?

Have students repeat the activity and substitute the #26 nichrome wire for the #32 nichrome wire.

What happened when the large-diameter wire was used in place of the small-diameter wire?

What will happen if other wires are substituted in place of nichrome?

Students should test the copper wire and a piece of coat hanger wire to compare to the nichrome.

Which wire conducts electricity best?

Materials:

For each pair of students:

D battery – 1
Battery holder – 1
#41 bulb – 1
#20 bare copper wire, 20 cm pieces – 3
#26 nichrome wire, 100 cm piece – 1
#32 nichrome wire, 20 cm piece – 1
Fahnestock clips – 2
Iron coat hanger wire, 20 cm piece – 1

Procedural Notes:

1) A simple tester can be constructed, as shown in the photograph.

2) The coat hanger wires may need to be scoured with steel wool if the wires have been painted or coated with an insulating substance.

SYLLABUS EMPHASIS	ACTIVITIES	SUPPLEMENTARY INFORMATION

Problem:

What property makes bulbs with different brightnesses?

Concepts:

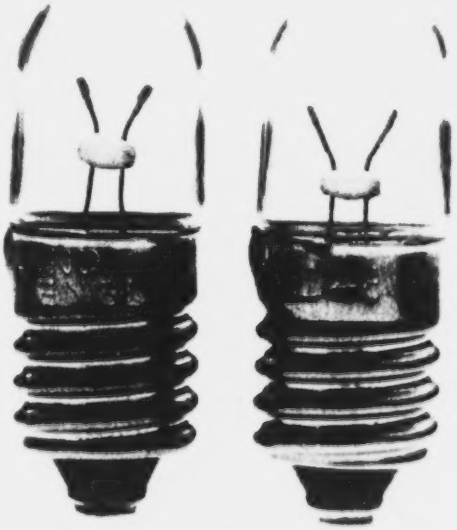
brightness
bulb
difference
filament
infer
insulator
similarity
terminal
watts

Skills/Processes	**Inquiry:** Inferring • Inferences are made to explain differences in bulbs. **Language Arts:** Communicating Information • Observations of bulbs are shared and explained.
Science Attitudes	A-1.33 Wanting explanations and interpretations of information that clarify and lead to accurate predictions. • Opportunities occur for students to question explanations and to appreciate the need to question explanations.
Science Understandings	II-D-3 When energy interacts with objects in a system, the properties of the objects may be changed. • Electricity flowing in a wire will cause the wire to become warm and to glow, such as in a clear incandescent light bulb.

5. BULBS

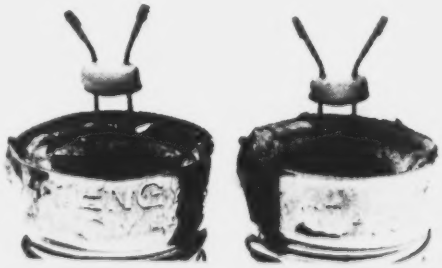
Help students recall their observations from Activity 2 that a #41 bulb and a #48 bulb did not glow with the same brightness when connected to the same battery.

Provide students with each of the two bulbs and magnifiers. Ask them to describe how the bulbs are similar and how they are different. Record the student descriptions on the board or on chart paper.



Ask students to describe how they think electricity from the battery moves through the bulb.

Show the class larger house-type bulbs that glow with different brightnesses. Students should become aware that the degree of brightness is related to the word "watts" on the glass "envelope" of the bulb. Students can inspect the filaments to identify similarities and differences.



Comparisons can also be made to burned out light bulbs.

Materials:

For each pair of students:

#48 bulb – 1
#41 bulb – 1
#20 bare copper wire, 20 cm pieces – 2
D cell battery – 1
Battery holder – 1
Bulb holder – 1
Magnifier – 1

For the class:

House-type bulbs of several sizes (25w, 60w, 100w)
Several burned out house-type bulbs
Screwdriver – 1
Heavy plastic or paper bag
Transparent tape

Procedural Notes:

1) If the initial observation did not occur in Activity 2, provide students with materials to conduct the investigation here.

2) It is not important to emphasize direction of electrical movement or poles. This concept will be developed in Level III.

3) The glass "envelope" can be removed from the house-type bulbs by shattering the envelope carefully while the bulb is in a heavy paper or clear plastic bag. A heavy object such as a hammer or screwdriver handle can be used to break the glass. Carefully discard all broken glass and tape the sharp edges to make the bulb safe to handle. Fasten a tag to the bulb base to identify its brightness in terms of watts.

4) The magnifier works best if it is held close to your eye and the object to be magnified is then moved closer or farther away until it is in focus.

5) It is not important to have students memorize the parts of the bulb, but their experiences should have established that each part is important in order for the bulb to light. The relationship to conductors and nonconductors will be made in a later activity.

4

SYLLABUS EMPHASIS Cont'd	ACTIVITIES Cont'd	SUPPLEMENTARY INFORMATION Cont'd

Class Discussion:

What happens to the bulb to cause it to produce light?

Which part of a bulb produces the light?

What causes the part to produce light?

Which kind of wire would be best for producing light?

What are the differences between bulbs of different brightnesses?

What are the differences between burned out bulbs and bulbs that light?

What seems to be the best explanation for the purpose of each part of a bulb?

Show the class a diagram of a #41 bulb as they infer the purpose of each part.

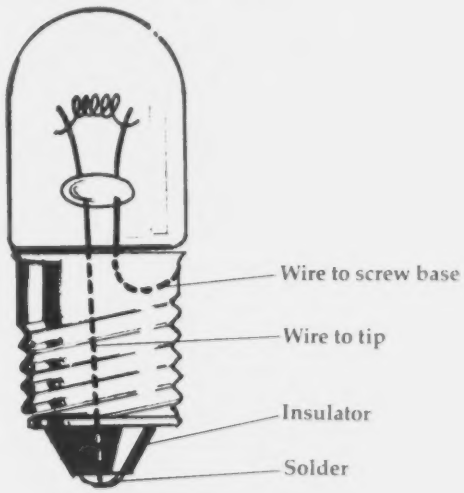


Diagram of a Bulb

Evaluation Strategy:

Individual

Each student will be able to state inferences to explain different brightnesses with different bulbs.

SYLLABUS EMPHASIS	ACTIVITIES	SUPPLEMENTARY INFORMATION

Problem:

How is a bulb constructed?

Concepts:

connection — hypothesize
construct — filament
energy transfer — resistance

Skills Processes	**Inquiry:** Formulating Hypotheses • Simple "if-then" statements are constructed. **Language Arts:** Communicating Information • Participating in brainstorming and discussion to develop "if-then" statements.
Science Attitudes	A-2.21 Valuing the use of investigative procedures that limit the risk to one's self, others, or the living and nonliving environment. • Establishing procedures and following them to avoid injuring themselves or damaging the batteries.
Science Understandings	II-D-3 When energy interacts with objects in a system, the properties of the objects may be changed. • Students see that electricity causes the filament in the bulb to become warm and to glow.

6. CONSTRUCTING A BULB

Ask students to recall the inferences they made in Activity 5 about properties of bulbs that produced different brightnesses. Ask students to describe how they could test their inferences with experiments to help prove or disprove the statements.

Discussion should follow with students describing how they would go about proving (or disproving) the statements.

Help students form some "if-then" statements they can use to help guide their experimentation. An example could be: "If I use a large (fat) wire for a filament, then it will glow brighter than a small (thin) wire."

Students may formulate several "if-then" statements as a result of the discussion. Each of these can become separate experiments.

Ask students what questions their "if-then" statements should try to answer. An example could be: "Will a fat-wire filament glow brighter than a thin-wire filament?" These questions can be used as the focus questions for the problems their experiments will try to solve.

Show students a setup with three batteries connected, as shown in the photograph below. Tell them to use a similar setup as the source of electricity to test their "if-then" statements. Indicate to them that three batteries will provide more electricity than one. Show the effect by momentarily connecting a light bulb to the three batteries.

Materials:

For each pair of students:

#20 bare copper wire, 20 cm pieces – 4
D batteries – 3
Battery holders – 3
#32 nichrome wire, 5 cm piece – 1
Plasticine
Clear plastic cup (optional) – 1

Safety Note:

Caution: During this activity nichrome wire becomes red hot. You may want the students to place a clear plastic cup over the filament so that nobody will get burned. Also, this setup will more closely resemble a bulb.

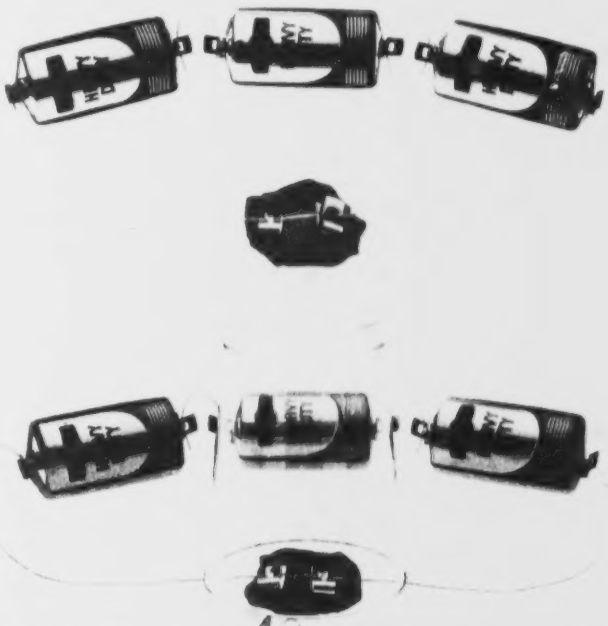
Procedural Notes:

1) Students should connect the nichrome wire before connecting batteries.

Students should only *momentarily touch connections* to the batteries. They should not leave the wire connected to the batteries. Leaving the batteries connected will discharge them rapidly and may also cause them to overheat.

2) Do not try to explain why three batteries provide more electricity. Nor does the difference between series or parallel circuits need to be explained at this level.

Circuitry will be dealt with in Level III.



SYLLABUS EMPHASIS Cont'd	ACTIVITIES Cont'd	SUPPLEMENTARY INFORMATION Cont'd
	Discuss the procedures they plan to use and focus on safety precautions to prevent injury to themselves and unnecessary damage to the batteries. After students have tested their "if-then" statements, conduct a discussion. **Class Discussion:** What happens to the filament when the wire from the bulb is connected to the batteries? Why does the filament glow? Which "if-then" statements were proved? Which "if-then" statements were disproved?	The three battery setup can be compared to two-or-three-battery flashlights that students may have used. 3) Incandescent bulbs are filled with an inert gas. This prevents the filament from burning out. The nichrome wire in the student's bulb will eventually burn out due to the oxygen in the air. Students may want to conduct research on gases inside various bulbs, if resource materials are available.
Evaluation Strategy: Group Students are able to make appropriate "if-then" statements about filament wire.		

SYLLABUS EMPHASIS	ACTIVITIES	SUPPLEMENTARY INFORMATION

Problem:

What is a fuse?

Concepts:

current
electricity
fuse
melt
safety
system

Skills Processes	**Inquiry:** Manipulating Materials • Batteries, bulbs, and wires are manipulated to observe interactions. **Language Arts:** Acquiring Information • The concept of fuse is developed as a result of library research and direct experience.
Science Attitudes	A-1.31 Wanting to know concepts, terms, techniques, and conventions useful in understanding the natural world. • Students try to learn how to test a fuse to understand its use.
Science Understandings	II-D-3 When energy interacts with objects in a system, the properties of the objects may be changed. • The wire in a fuse may become too hot and melt or burn, thus stopping the flow of electricity.

Evaluation Strategy:

Group, Program

Students are able to describe the purpose of a fuse and demonstrate its use.

7. MAKING A FUSE

Ask students to share their connotations of the word "fuse." These descriptions can be written on the chalkboard or on chart paper for reference in this activity.

Send students to sources of information such as dictionaries or encyclopedias to identify definitions for the word. These also can be placed on the board or on chart paper.

Ask students to identify which meanings from their list or from the information sources are associated with electricity.

Ask students to brainstorm how they might build a fuse and test it. Help them recall experiences already gained in earlier activities that could be applied here.

Show students a model setup, similar to the photograph below, that could be used to test fuses.

Provide students with materials to construct and test their fuses.

Class Discussion:

What is the evidence that electricity is flowing from the battery?

What is the evidence that the amount of electricity flowing can be made larger or smaller?

What effect does electricity have on the fuse wire material?

Where are fuses used? (What objects or devices have fuses?)

What is the purpose of a fuse?

What safety rules should be followed regarding fuses?

Materials:

For each pair of students:

#20 bare copper wire, 20 cm – 7 pieces
#48 bulbs – 2
#41 bulb – 1
D batteries – 3
Battery holders – 1
Clear plastic cup or glass (optional) – 1
Strands of steel wool
Fahnestock clips – 2
clips.

Procedural Notes:

1) Make sure the steel wool strand stays in contact with wires X and Y.

Steel wool strands get red hot, melt, or burn. Students should put a clear plastic glass or cup over the fuse to avoid any kind of injury.

2) Students can be shown how to have three batteries hooked together as shown in the diagram and then "tap" one battery, two batteries at a time, and finally all three to increase the electricity flowing through the fuse.

3) Fuses must be replaced when "blown." Many new buildings and electrical devices use circuit breakers, which can be reset. These act as safety devices.

Safety Note:

Examples of safety rules could be identified from sources such as the power company, manufacturers, catalogs, instruction manuals for fuse-protected equipment, or an automobile operation manual from the manufacturer. Some basic rules might include:

1. Don't bypass a fuse.
2. Use the correct size of fuse.
3. If fuses blow regularly, disconnect some of the objects that are in the system.
4. If you aren't sure what is wrong, ask someone who knows.

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SYLLABUS EMPHASIS	ACTIVITIES	SUPPLEMENTARY INFORMATION

Problem:

Which solids conduct electricity?

Concepts:

conduct
conductors
indirect
insulate
nonconductors
observation
predict
solid
tentative

Skills Processes	**Inquiry:** Observing • Students extend their power of observation by use of a light bulb to sense electricity. **Language Arts:** Developing Vocabulary • Meaning will be added to common terms such as "conductor."
Science Attitudes	A-2.11 Accepting information and ideas about the natural world as uncertain and valuing verification and supporting reasons. • Students test claims, using different solids to verify or disprove predictions.
Science Understandings	II-C-2.2 Energy can move from one object to another through materials and through space. • Electricity moves more easily through some solid materials such as metal conductors and does not move easily through materials such as rubber and glass, which are insulators.

Evaluation Strategy:

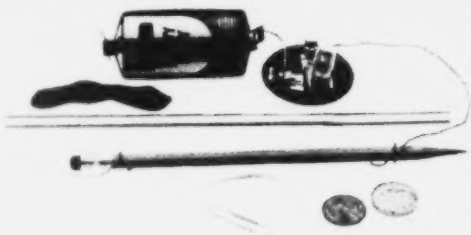
Individual

Given a group of several solid objects of known material, students will be able to identify conductors and nonconductors of electricity, using a physical test.

8. SOLID CONDUCTORS AND NONCONDUCTORS

Help students devise a plan to answer the question. They might start with prediction lists of objects that can then be tested.

Provide students with materials to construct the tester shown below.



Students should test the materials at their own pace, recording results and accumulating evidence to apply to the predictions.

Class Discussion:

How can you decide which solids conduct electricity?

What similarities are found among the materials that conduct electricity?

What similarities are found in the materials that do not conduct electricity?

Which materials produced different results than were predicted? How could this be explained?

What other materials not tested might be predicted to be conductors or nonconductors?

Materials:

For each pair of students:

#20 bare copper wire, 20 cm pieces – 3
Bulb holder – 1
#48 bulb – 1
D battery – 1
Battery holder – 1
Variety of objects, including pencils, erasers, paper clips, clay, scissors, crayons, etc.

Procedural Note:

The materials and test setup for this activity are similar to those used in earlier activities. Students should experience little difficulty in moving from the earlier activities into this one, once the problem is identified and the plan established.

Safety Note:

Review common sense safety rules established in the earlier activities.

Background Information:

1) Most metals are good conductors of electricity. Rubber and plastic products are generally poor conductors of electricity.

2) Some objects are at times conductors and at times insulators, depending on the number of batteries used.

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SYLLABUS EMPHASIS	ACTIVITIES	SUPPLEMENTARY INFORMATION

Problem:

Which liquids conduct electricity?

Concepts:

conduct
conductor
indirect
insulate
liquid
nonconductor
observation
predict
tentative

Skills/Processes	**Inquiry:** Observing • Students extend their power of observation by use of a light bulb to sense electricity. **Language Arts:** Communicating Information • Accumulated evidence is shared among students.
Science Attitudes	A-2.11 Accepting information and ideas about the natural world as uncertain and valuing verification and supporting reasons. • Students test claims, using different liquids to verify or disprove predictions.
Science Understandings	II-C-2.2 Energy can move from one object to another through materials and through space. • Electricity moves more easily through some liquid materials such as salt solutions, and does not move easily through liquid materials such as oils. Dilute solutions may be poorer conductors than concentrated solutions.

Evaluation Strategy:

Individual

Given a group of several liquids, students will be able to identify conductors and nonconductors, using a physical test.

9. LIQUID CONDUCTORS AND NONCONDUCTORS

Help students devise a plan to answer the question. They might start with prediction lists of liquids that can be tested.

Provide students with materials to construct the tester shown below.

Each plastic tumbler should be filled to a depth of approximately 3 cm with the liquid to be tested.

Clip X Clip Y

Students should test the liquid materials at their pace, recording results and accumulating evidence to apply to the prediction.

Class Discussion:

How can you decide which liquids conduct electricity?

What similarities are found among the liquid materials that conduct electricity?

What similarities are found among the liquid materials that do not conduct electricity?

Which liquids produced results different from what was predicted? How could this be explained?

What other liquid materials, not tested, might be predicted to be conductors or nonconductors?

What safety rules should be observed when involved with liquid conductors?

Materials:

For each pair of students:

#20 bare copper wire, 20 cm pieces – 6
Battery holders – 4
#48 bulb – 1
Bulb holder – 1
D batteries – 4
Plastic tumbler – 1
Fahnestock clips (X,Y) – 2
Paper towels
Powdered cleanser
Variety of liquids such as: vinegar, water, salt in water, baking soda in water, cooking oil, liquid soap, powdered cleanser in water

Procedural Notes:

1) This activity is nearly parallel with solid conductors and nonconductors. The two could be run simultaneously if desired, although extra care must be taken to manage the more diverse activities that will result.

2) Students must not connect clips X and Y because the circuit will then automatically conduct electricity.

The X and Y Fahnestock clips should be held very close together but not touching when testing the solutions. If you look carefully, you will observe a faint glow of the bulb in some cases.

For best results, the flat sides of the Fahnestock clips should face each other.

3) Tumbler and X and Y Fahnestock clips should be washed between tests. Do not mix liquids.

4) Liquids brought in from home can also be tested. Some interesting liquids are: tap water, lake water, milk, coffee, orange juice, and sugar syrup.

Cooking oil or other sticky, thick liquids can be used, but they will require careful cleaning of the tester before a new liquid is used.

Safety Notes:

1) Corrosive, caustic, and poisonous liquids should not be used.

2) Electrical devices such as radios or electrical toys should never be used in areas that are wet.

SYLLABUS EMPHASIS	ACTIVITIES	SUPPLEMENTARY INFORMATION

Problem:

What is insulated wire?

Concepts:

application	electricity
conductor	insulate
connection	nonconductor

Skills/Processes	**Inquiry:** Creating Models • Models are constructed for insulated wire. **Language Arts:** Communicating Information • Students share thoughts on questions for discussion.
Science Attitudes	B-1.2 Valuing resourcefulness and innovativeness in the solution of practical problems. • Students express the value of the innovation of insulated wire by speculating on the consequences of not having it.
Science Understandings	II-C-2.2 Energy can move from one object to another, through materials and through space. • Insulated wire uses conductors and nonconductors to move electricity to where it is desired.

Evaluation Strategy:

Group

Students are able to describe the purpose of the parts in insulated wire.

10. ELECTRICAL DEVICES – INSULATED WIRE

Ask students to think about two questions: "How can we make electricity go where we want it to go?" and "How can we keep electricity from going where we don't want it to go?" Write the two questions on the board or chart paper for reference. Let students describe their answers (or thoughts) to the questions in a general class discussion.

Help students bring a focus to the discussion by asking, "What devices help us accomplish the two tasks?"

Ask students to bring available pieces of wire from home (6-8 inches in length). Pass the samples among the class for examination.

Class Discussion:

Which parts of the wires make electricity go where we want it to go?

Which parts of the wires keep electricity from going where we don't want it to go?

What model(s) represents the pieces of wire? (This question leads to the activity.)

Provide students with materials to construct models of insulated wire.

Models that may result from student construction are shown below.

What is the purpose represented by each part of the model(s) of insulated wire?

What would be the consequences if insulated wire had not been invented?

What are the advantages and disadvantages of each type of insulating material?

Which type of insulating material used in the real insulated wire samples seems to be best?

Materials:

For each pair of students:

#20 bare copper wire, 20 cm – 3-4 pieces
#48 bulb – 1
Bulb holder – 1
D battery – 1
Battery holder – 1
Soda straw – 2
Plasticine
Tape, masking or transparent
Paper strips

Procedural Notes:

1) Students will have used bare wire for most of the activities in their unit. The need for insulated wire may not have become apparent. It may be useful to discuss consequences of using uninsulated wire and relate them to the earlier activities. Use "What would happen if...?" questions, such as "What would happen if two wires going to a bulb from the battery touched each other?"

2) Pieces of wire from home can be scrap pieces rather than complete cords. Examples could include house wire, lamp cord, TV wire, TV cable, speaker wire, etc.

SYLLABUS EMPHASIS	ACTIVITIES	SUPPLEMENTARY INFORMATION

Problem:

What is an electrical switch?

Concepts:

closed
conductor
contact
dimmer
liquid conductor
open
switch

Skills/Processes	**Inquiry:** Creating Models • Model electrical switches are constructed. **Language Arts:** Recording Data • Students draw simple diagrams to explain how switches work.	
Science Attitudes	B-1.3	Caring about efficiency, simplicity, and dependability of techniques. • Appreciation of the simplicity of electrical devices such as switches.
Science Understandings	II-D-2	Energy in a particular form can be transferred from one object to another in a system. • Electrical switches transfer the flow from one connection to another, or stop the flow.

11. ELECTRICAL DEVICES – SWITCHES

Ask students to share their understanding of the word "switch." These descriptions can be written on the chalkboard or on chart paper for reference in this activity.

Send students to sources of information such as dictionaries or encyclopedias to identify word definitions. These can be placed on the board or on chart paper.

Class Discussion:

What are the most common similarities for the meanings of the word?

Which meanings from the list are associated with electricity?

Have students collect pictures from catalogs, advertisements, and magazines to make a collage. The collage should illustrate an answer to the question, "How many different kinds of electrical switches are there?"

Obtain samples of electrical switches from home, hardware stores, or local electricians for display.

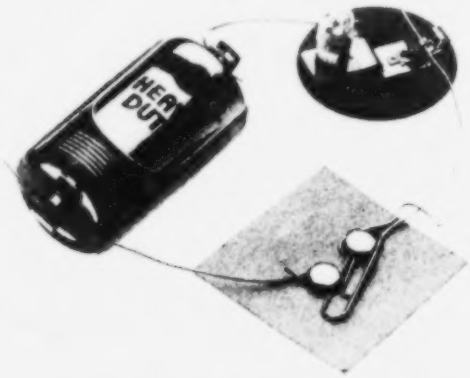
What are the common similarities among the sample switches?

Ask students to brainstorm plans to construct model switches of the simple contact, dimmer, and liquid types.

Suggest to students that they use information gained in earlier activities to help them devise the models. Recall outcomes from Activities 4, 8, and 9.

Provide materials as needed to enable students to construct simple contact switches.

Models might resemble the photograph below.



Materials:

For each pair of students:

#20 bare copper wire, 20 cm piece – 3 or 4
#32 nichrome wire, 20 cm piece – 1
#48 bulbs – 1
D batteries – 2
Battery holders – 4
Bulb holders – 2
Fahnestock clips – 2
Paper clips – 2
Plastic straw, 5 cm piece – 1
Wad of plasticine – 1
Paper fasteners
Cardboard square, 2" x 2" – 2 pieces
Liquid conductor

Procedural Notes:

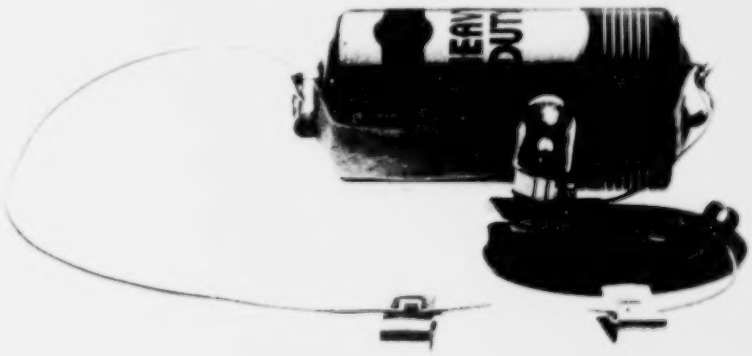
1) This activity should focus on the simplicity of electrical switches and the application of materials, because of their properties, in making switches.

2) Time should be taken to review outcomes of earlier activities in order for students to appreciate the application of principles learned earlier to the problem of devising various kinds of switches.

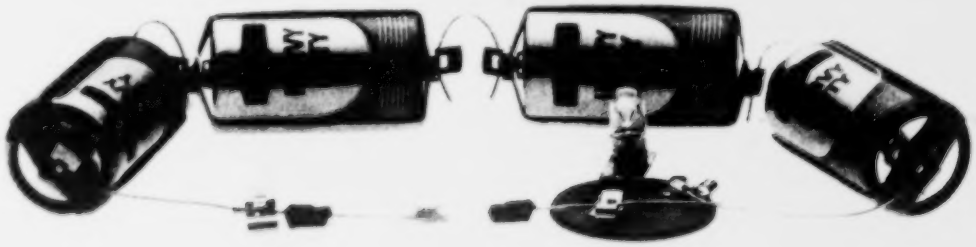
3) The outcomes of this activity should be limited only to switches as objects such as batteries and bulbs. More detailed consideration of circuits occurs in Level III.

SYLLABUS EMPHASIS Cont'd	ACTIVITIES Cont'd	SUPPLEMENTARY INFORMATION Cont'd

Provide materials as needed to enable students to construct a dimmer-type switch. Models might resemble the photograph below.



Provide materials to students as needed to enable them to construct a liquid-type switch. Models might resemble the photograph below.



Class Discussion:

What are the main purposes of electrical switches?

What other nonelectrical devices have a purpose similar to electrical switches?

Evaluation Strategy:

Group

Students will be able to state purposes of electrical switches.

APPENDIX

MAKING A BATTERY HOLDER

Materials:

#82 rubber band – 1
Fahnestock clips – 2

Procedure:

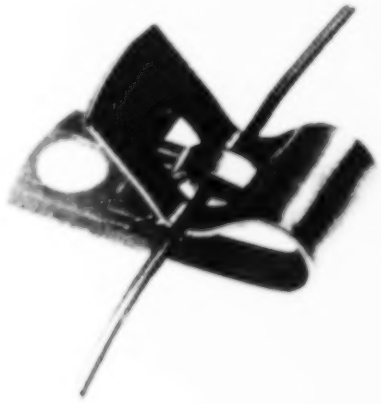
Make a battery holder as shown in the photographs. Spread the Fahnestock clip apart to allow the rubber band to be slid into the clip. Position the clips so that they are opposite each other on the unstretched rubber band.

Carefully stretch the rubber band with clips and place over the ends of a D cell. The bottom of each clip should make good contact with the end of the battery.

The Fahnestock clip spring can be bent downward to allow a wire conductor to be inserted. The spring should hold the wire conductor firmly when released.

Caution:

It is not advisable to try to stretch the rubber band with the clips over more than one battery, even though the band might stretch that far. If an overstretched band snaps off the battery, it could harm someone.



II	BUTTERFLIES	

BUTTERFLIES

LEVEL II _____ (GRADE)

PROBLEM OVERVIEW

The butterfly is a common and colorful part of most children's experience with the natural world. Although many children may think they know a lot about butterflies, it is unlikely that they have had an opportunity to closely observe butterflies or to learn about their life cycle in a controlled environment. Consequently, the butterfly's life cycle may seem mysterious to them. This unit can provide the opportunity to remove some of the mystery by helping children gain a better understanding about and increased appreciation of another creature of the natural world.

SUGGESTED SCHEDULE/SYLLABUS EMPHASIS

#	Activity Title	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Emphasis
1	Facts, Myths, and Questions							Making Decisions/Questioning A-1.32 Accurate information II-A-2.1 Generation, stages, life cycle
2	Planning the Care of Butterflies							Making Decisions/Communicating Information A-1.21 Individual life, precious II-A-2.1 Generation, stages, life cycle
3	The Larva							Observing/Recording Data A-1.32 Accurate information II-A-2.1 Generation, stages, life cycle
4	Animals Depend on Plants							Predicting/Recording Data A-2.11 Uncertainty of information, verification II-B-1 Plants, animal food supply, sun energy
5	The Pupa							Observing/Communicating Information A-1.11 Complexity, diversity, intricacy, etc. II-A-2.1 Generation, stages, life cycle
6	The Adult							Observing/Communicating Information A-1.11 Complexity, diversity, intricacy, etc. II-A-2.1 Generation, stages, life cycle
7	Butterfly Eggs							Observing/Communicating Information A-1.32 Accurate information II-A-2.4 Animal potential for offspring
8	Completion of the Life Cycle							Creating Models/Classifying A-1 Understanding, natural world II-A-2.1 Generation, stages, life cycle
9	Returning to the Natural Environment							Making Decisions/Communicating Information A-1.2 Respecting life II-A Plants, animals, new generations

SUGGESTED APPROACH

Butterfly larvae must be ordered several weeks in advance. Larvae and culture medium are available from science supply houses. Since the painted lady butterfly can be grown easily in captivity, it is the species usually available and is the species used in this unit. The unit is best done in spring or fall when environmental conditions are better for butterflies.

Several weeks before the unit begins, consult the librarian to determine what books, computer software, and media materials about butterflies are available, with special emphasis on myths and superstitions. If possible, arrange for the materials to be delivered to the classroom or placed on reserve in the library. Include materials from a wide range of reading levels to provide background for students with varying abilities. The librarian may want to use butterflies as the focus for a required library skills unit.

The unit can start by having students pool the knowledge they already have, or think they have, about butterflies. The listing of myths, superstitions, suppositions, and factual information can serve as discrepancies to be resolved. For example, students may be surprised by what arrives in the mail as the "ordered butterflies." Comparisons can and should be made with animals students have studied previously or animals with which they are familiar. Students can, for example, determine how butterflies are like or unlike mealworms.

MATERIALS

Cotton swabs – 1 bag
Nylon mesh – 6 sq. meters
Dropper bottles – 2
Granulated sugar – 1 1/2 pints
Cotton balls – 1 small bag
Petri dishes – 12 small
Hand lenses – 12
Plastic spoons – 8
Culture containers with lids – 15
Butterfly larvae – 1 per 2 students
Butterfly culture medium – 1 pint
Filter paper or hair-setting tape
Paper punch
Paper clips
Paper fasteners
Cardboard boxes (approx. 45 x 30 x 25 cm) or shoe boxes – 6
Masking tape
Potting soil
Mallow plants and other plants
Box knife
Plastic aquarium
Plastic wrap
Scissors
String
Poster paper
Captured butterfly (by teacher) or pictures of butterflies
Rulers (centimeter scale)

MORE IDEAS

1. Check your local library to find books, filmstrips, pictures, computer software, etc. to supplement the classroom activities.

2. Have students collect poems about butterflies or moths for a poetry anthology.

3. Have students write their own poems about butterflies.

4. Conduct a discussion on survival, including the idea that not all living things will develop or live to reach maturity, and the limiting factors by which populations are controlled.

5. Create classroom bulletin boards of commercial and students' works.

6. Have students develop reports, compositions, or visual presentations on butterflies, or have students write a book about butterflies. Include topics and ideas from the insect's viewpoint, such as "My First Flight," "Why My Antennae Are Knobbed," "How I Felt as a Caterpillar." Students may also write a "wordless" book. Ruth Heller's book, *Butterflies*, is an example of a wordless book that provides a high content level.

7. Have students produce models of the insect's life cycle.

8. Conduct a guided imagery experience with students on how it feels to be a butterfly as it develops from egg to actual butterfly. Develop a visualization narrative and read it to students as a prewriting activity. (See "Guided Imagery in the Curriculum," by B. Galyean, *Educational Leadership*, March, 1983, pp. 54-58.)

9. Have students plant a butterfly garden. Research which plants butterflies (including the caterpillar stage) feed on, then order seeds or small plants from a plant catalog or nursery. Check local gardens and open fields for plants that can be transplanted to the garden. Plant and tend the garden, then observe, record, and analyze what happens.

SYLLABUS EMPHASIS	ACTIVITIES	SUPPLEMENTARY INFORMATION

Problem:

What facts, myths, and questions do people have about butterflies?

Concepts:

butterfly
caterpillar
fact
superstition
myth
pupa

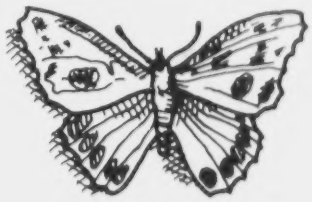
Skills Processes	**Inquiry:** Making Decisions • Students decide what questions about butterflies they will investigate. **Language Arts:** Questioning • Students develop a list of questions which indicate what they want to find out about butterflies.
Science Attitudes	A-1.32 Wanting accurate and thorough information about the natural world. • Students raise questions about butterflies which are of interest to them.
Science Understandings	II-A-2.1 Each generation of animals goes through changes in form from young to adult. The adult gives rise to the young of the next generation. This completed sequence of changes in form is called a life cycle. • Many student questions will focus on the changes a butterfly goes through during its life cycle.

Evaluation Strategy:

Group, Program

Students are able to make decisions about which questions they want to investigate and to plan how they will investigate the questions they choose.

1. FACTS, MYTHS, AND QUESTIONS



Painted Lady Butterfly

A few days before larvae arrive, conduct a discussion with students about their experiences with butterflies.

If possible, capture a butterfly to show to the class (then release it the next day). Otherwise, show numerous pictures of a butterfly.

Class Discussion:

After looking at the butterfly, what is your reaction? What is the first word that comes to your mind? Why do you think this word came to your mind?

Make a chart of the words chosen by the students.

Discuss the suggested words (possible words: beautiful, pretty, colorful). Use this list to describe the class attitude toward butterflies.

Help students brainstorm what they already know about butterflies. Ask them to survey other students, teachers, and family members for myths and superstitions about butterflies. Make a master list of what students know (or think they know) about butterflies.

What seems to be fact in the list? Myth? Superstition? How can we find out?

Which items in the list do we want to find out more about? Determine if they are fact?

What other questions do we have about butterflies? Which questions do we want to investigate? How will we decide which questions to investigate?

How will we investigate these questions? What information do we already have? What new information do we need? What is our plan?

Materials:

Captured butterfly, pictures of butterflies for display, and resource materials

Procedural Notes:

1) This initial activity should serve to identify any discrepant information about butterflies which students have already acquired or which is noted as they share their knowledge about butterflies. Students may ask, "Is that (fact) really true?" or state, "I thought the opposite was true." The investigations students plan can then be used to confirm or reject what they classified as fact, or to answer questions raised.

2) Typical questions which students might raise are:

What are the different kinds of butterflies?
Where are butterflies found?
What do butterflies eat?
Can we raise butterflies in the classroom?
How do we care for the butterflies?
Where do butterflies come from?
How is a butterfly different from a moth?
What happens to a butterfly when it gets cold?
Do butterflies migrate like birds?
How does a butterfly change in form?
What *don't* we know about butterflies?
How does the class feel about caterpillars?
What does a caterpillar eat?
Are butterflies and caterpillars insects?
How large is a butterfly's neighborhood?
Why are butterflies called "butter flies?"

While all student questions can be investigated, and students should be encouraged to investigate those of most interest to them, the remaining activities in this unit focus on the questions which can be pursued through direct classroom experiences with butterflies.

3) Small groups of students can be encouraged to investigate individual questions (which are really problems) in the master list, while the class as a whole works on other questions (problems), such as the following activities in this unit. A culminating activity might be a class sharing of what these small groups have learned about butterflies.

SYLLABUS EMPHASIS	ACTIVITIES	SUPPLEMENTARY INFORMATION

Problem:

How should butterflies be cared for in the classroom?

Concepts:

care
handling
respect for life

Skills/Processes	**Inquiry:** Making Decisions • Students identify methods for proper care and handling of butterflies. **Language Arts:** Communicating Information • Students will be communicating their attitudes about the proper care and handling of animals.
Science Attitudes	A-1.21 Respecting each individual life as precious to the individual and others. • The students will be showing respect for the butterfly's life by listing rules for its proper care.
Science Understandings	II-A-2.1 Each generation of animals goes through changes in form from young to adult. • Care and handling of each stage of the butterfly's life cycle must be planned for to ensure that the butterfly lives.

Evaluation Strategy:

Individual

The student is able to demonstrate an understanding of the care and handling of the butterflies according to the plan developed.

2. PLANNING THE CARE OF BUTTERFLIES

Just before the butterflies arrive, or in conjunction with their arrival, spend some time discussing with the class how the butterflies should be cared for and who will take care of them. Emphasize how delicate the larva, pupa, and adult butterflies are.

Make a plan for the proper care and handling of the butterflies as the students raise and investigate them in the classroom. Include in the plan the specific tasks that students will be responsible for in caring for the butterflies. Help students to choose which task to be responsible for and then help each student to assume this responsibility.

Once the plan is developed, ask students to make a large classroom poster to remind them of the rules for proper care and handling of the butterflies.

Materials:

Poster paper (provided by teacher)

Procedural Note:

A class plan for the proper treatment of butterflies might look like the following:

HUMANE TREATMENT OF BUTTERFLIES

1. Treat a butterfly as you would treat another person.
2. Do not touch the butterflies.
3. Handle the butterfly containers carefully.
4. Keep the butterfly containers clean.

SYLLABUS EMPHASIS	ACTIVITIES	SUPPLEMENTARY INFORMATION

Problem:

What are the butterfly larvae like?

Concepts:

caterpillar
culture container
growth
larva
protection

Skills Processes	**Inquiry:** Observing • Some of the students' questions are answered as they observe the larvae. **Language Arts:** Recording Data • The students will be recording data as they observe the larvae.
Science Attitudes	A-1.32 Wanting accurate and thorough information about the natural world. • The students will study the larvae, making accurate observations and gathering accurate data.
Science Understandings	II-A-2.1 Each generation of animals goes through changes from young to adult. • The students will be studying the larva stage of the butterfly.

Evaluation Strategy:

Individual

Students are able to state several observations and inferences they have made about the larvae.

3. THE LARVA

Painted Lady Larva

Preparing the Larvae Containers

1. Use plastic spoons to pack the green culture medium from the stock jar into the culture containers to a height of about 1 cm.
2. Use a cotton swab to transfer very gently one or two larvae into each container.
3. Press the lid until it snaps in place.
4. The culture containers may be opened for observation purposes.

Observing the Larvae

Students may keep the butterfly larvae containers on their desks so the larvae can be observed daily. The containers can be taped to the desks. Encourage the use of magnifiers to make observations.

Students should keep a notebook containing their daily observations of the larvae (including drawings).

Careful observation of the larvae will answer many of the questions (problems) raised by the students in Activity 1. Help students to identify which questions can be answered by observation and/or inference from observation. Encourage class discussion of these questions and the students' observations which help answer them. Such questions may include:

How many legs does a larva have? Are all the legs the same?
Would a bird eat a larva? Why or why not?
How does a larva protect itself from being eaten by other animals?
Does a larva grow? (Students can use string to measure the length of a larva two times a week. This information can then be recorded on a bar graph.)
Does the larva have a mouth?
What is the purpose of the webs that the larva makes in the culture vessel?
How does the container environment meet the needs of the larva?
Does the larva need adult butterflies to survive?

Materials:

Culture medium (food) – 1 pint
Plastic spoons – 8
Cotton swabs – 15
Live butterfly culture – 15
Culture containers with lids – 15
String
Hand lenses – 12
Rulers (centimeter scale)
Paper punch
Filter paper or hair-setting tape

Preparation Notes:

The culture containers should be adapted in advance as follows:

1) Use a punch to make an air exchange hole in the plastic lid of the container.

2) Since larvae will be able to escape through this hole, tape it over on the inside with filter paper or hair-setting tape (which is adhesive on one side).

Procedural Notes:

1) As soon as the larvae arrive, students should work in pairs to prepare the containers and to transfer the larvae to them. *Impress upon the students that butterflies are very fragile in all stages of their life cycle. Students should never pick up or touch the larva, pupa, or adult at any time.*

2) Some students with handicapping conditions may profit from prediscussion activities that focus their responses to previously raised questions in Activity 1. These prediscussion activities can take place in their special education classes.

SYLLABUS EMPHASIS	ACTIVITIES	SUPPLEMENTARY INFORMATION

Problem:

What do the larvae eat?

Concepts:

food
growth

Skills/Processes	**Inquiry:** Predicting • Students predict what they think the butterfly larvae will eat. **Language Arts:** Recording Data • The students will be noting which plant leaves the larvae do and do not eat.
Science Attitudes	A-2.11 Accepting information and ideas about the natural world as uncertain and valuing verification and supporting reasons. • The students test their predictions through direct experimentation and observation.
Science Understandings	II-B-1 The plants in a given area provide the basic food supply for animals because only plants can manufacture food by utilizing the sun's energy. • The students determine that the mallow plant is the natural food supply for the larvae of the painted lady butterfly.

Evaluation Strategy:

Individual, Group

Students are able to identify one plant as the food source of the larvae and to note that this is significant because only plants make food.

4. ANIMALS DEPEND ON PLANTS

Students will probably be working on the problem of what the larvae eat. Typical questions are:

What do the larvae eat in the container?

What would the larvae eat if they lived outside? How could we find out?

After students have determined what the larvae eat in the container, take the class on a short walk around the school. Have each student find one leaf of a plant they think the larvae will eat. (Make sure some students try mallow leaves.)

Students should place a 3 cm or smaller portion of each leaf in the culture vessel to see if the larva eats it. Observe and discuss the results.

Once it has been determined that larvae eat mallow leaves, students may wonder how many mallow leaves the larvae will eat. Students can dig up a mallow plant, plant it in a medium-sized pot, and count the number of leaves it has. Place the potted mallow plant in an empty aquarium. Place several larvae on the mallow plant. Cover the top of the aquarium with plastic wrap. Each day, students can determine and graph the number of leaves eaten by the larvae. Within days, students should see the entire mallow plant devoured by the larvae.

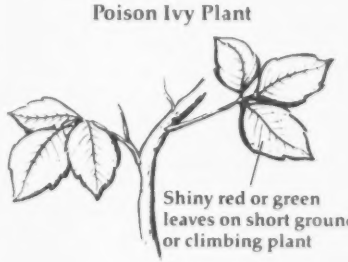
Class Discussion:

What do the larvae eat in the container?

What do the larvae eat out-of-doors?

How much do the larvae eat each day?

What would happen to larvae living out-of-doors if all the mallow plants disappeared?



Materials:

Culture containers (with larvae)
Mallow plants and leaves from other plants
Aquarium
Plastic wrap

Safety Note:

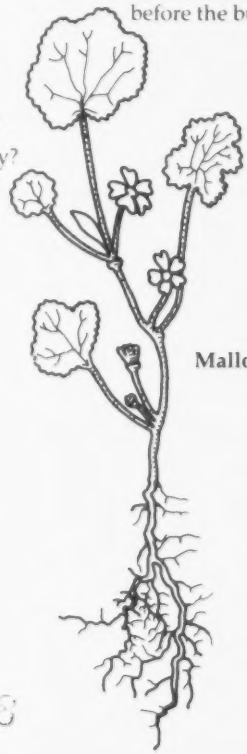
Make sure that students do not pick poison ivy or sumac leaves when collecting leaves for larvae.

Procedural Notes:

1) In the container, larvae eat the green culture medium. In nature, painted lady butterfly larvae feed on mallow plants. Mallow is a creeping plant with geranium-shaped leaves and small pink flowers. The seeds of mallow are grouped in circular clusters resembling small round cheeses. Mallow is commonly found in school lawns and close to building foundations. Mallow may also be found in flower and vegetable gardens and around plantings of shrubs.

2) If mallow plants cannot be found locally, or to ensure an adequate supply, mallow seeds (*Malva alcea fastigiata*) can be ordered from a seed company well before the butterflies are ordered, then planted several weeks before the butterflies arrive.

3) Painted lady larvae also eat hollyhock leaves and leaves of common thistles.



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SYLLABUS EMPHASIS	ACTIVITIES	SUPPLEMENTARY INFORMATION

Problem:

What happens to the larvae as they grow older?

Concepts:

attach
chrysalis
develop
growth
pupa (pupae)

Skills Processes	**Inquiry:** Observing • Students continue to make observations and record data as the larvae form pupae. **Language Arts:** Communicating Information • Class discussion allows each student to share in observations that may have been missed individually.	
Science Attitudes	A-1.11	Appreciating the natural world, its complexity and diversity, its lawfulness and consistency, and its intricate detail and vastness.
	• Students will marvel at the great change from larva to pupa.	
Science Understandings	II-A-2.1	Each generation of animals goes through changes in form from young to adult.
	• The pupa is not a resting stage, but rather a stage during which the larva undergoes great physical change.	

Evaluation Strategy:

Individual

Students are able to express in their own words the wonder of the larva changing into a pupa.

5. THE PUPA

Painted Lady Pupa

Shortly before the larvae pupate, discuss with the class their data on the growth of the larvae. Ask students to predict the larval growth over the next week or so.

Make sure that students continue to observe the larvae daily and that they record the behavior of the larvae. Eventually, students will observe the larvae attaching themselves to the lid of the container and developing into pupae. All observations (including drawings) should be recorded in students' notebooks.

Class Discussion:

How fast were the larvae growing?

What were your predictions for continued larval growth?

What happened to the larvae as time went by?

Could you tell they were going to form pupae? If so, how?

What happened when they formed pupae?

Why do the pupae have to be transferred to the butterfly cages?

Materials:

Larvae containers
Butterfly cages
Hand lenses – 12

Preparation Note:

When the larvae enter the pupa stage, they must be transferred to butterfly cages. Directions for preparing the cages appear in the appendix to the unit.

Procedural Notes:

1) Two or three weeks after arrival, the larvae will suspend themselves upside down from the lid of the culture container and form a pupa (chrysalis). When this occurs, the teacher should *carefully* remove the lids from the containers and tape them to the inside top of the butterfly cages so that the pupa remains hanging upside down.

2) Caution students not to remove the container lids once the larvae have attached themselves to the lids.

3) Caution students that bumping the cage or table can cause the pupae to fall from the lids. Remind students not to touch the pupae.

4) If students ask why the larvae form pupae, discussion may suggest that science does not provide all the answers to the mysteries of life.

SYLLABUS EMPHASIS	ACTIVITIES	SUPPLEMENTARY INFORMATION

Problem:

What happens to the pupa?

Concepts:

adult	feeding
antennae	metamorphosis
emerge	proboscis

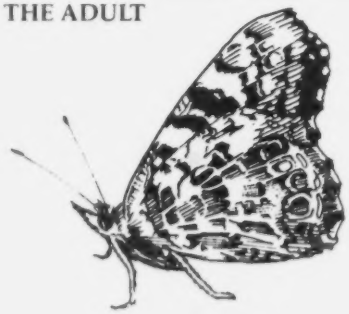
Skills/Processes	**Inquiry:** Observing • There is much to observe and record as the adult butterfly emerges and later feeds. **Language Arts:** Communicating Information • Students discuss observations, such as the twitching of pupae and fluid leakage.
Science Attitudes	A-1.11 Appreciating the natural world, its complexity and diversity, its lawfulness and consistency, and its intricate detail and vastness. • The wonder of the process of metamorphosis is apparent to students as they observe the emerging adult.
Science Understandings	II-A-2.1 Each generation of animals goes through changes in form from young to adult. The adult gives rise to the young of the next generation. This completed sequence of changes in form is called a life cycle. • The transformation from caterpillar to adult butterfly demonstrates a marked change from one stage to the next.

Evaluation Strategy:

Individual

Students are able to express in their own words the wonder of the butterfly emerging from the chrysalis.

6. THE ADULT



Painted Lady Adult

Discuss with the students their observations of the pupae. Ask students to predict what will happen next.

Make sure that students continue to observe the pupae daily and that they record their observations. Eventually the adult butterflies will emerge from the pupae. Students should observe the emergence (if possible) and record their observations (including drawings) in their notebooks.

Students should then continue to observe the butterflies every day and record their observations, especially as the butterflies feed.

Help students to observe all the body parts of the butterflies.

Allow students to continue to investigate the problems they have raised about butterflies, such as determining what other foods they eat, or what concentrations of sugar water.

Class Discussion:

What happened to the pupae? How could you tell something was going to happen?

How does a butterfly locate food?

How does a butterfly know if something is food?

What do butterflies eat?

How does body color help or hurt a butterfly?

Does a butterfly hear? Which body part do you think helps a butterfly to hear?

Which body part helps a butterfly to feel?

What is the function of the body part called the proboscis? (It is the feeding tube that draws up the liquid food.)

How does each body part of the butterfly contribute to the functioning of the entire organism?

Materials:

Cages with pupae
Cotton balls – 1 small bag
Granulated sugar – 1 1/2 pints
Dropper bottle
Petri dishes – 12 small

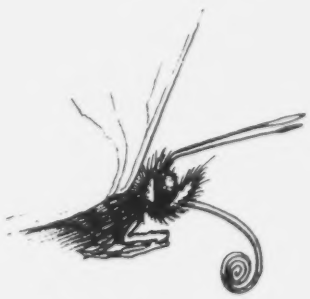
Preparation Note:

To prepare food for the adult butterflies, fill the dropper bottles with water and add 1 tsp. sugar to each bottle (20 parts water to 1 part sugar). Shake until sugar is thoroughly mixed with water. To prepare feeder stations, place a cotton ball in a Petri dish. Put two or three feeder stations in each cage. Place a few drops of solution on each feeder station each day. The butterflies will soon come to the feeder station and unroll their proboscises to feed.

Procedural Notes:

1) Adult butterflies will emerge from the pupae in 7 to 10 days. Usually the pupa will begin to twitch several hours before the butterfly emerges.

2) The butterflies can be injured easily at this time and should not be touched. The butterflies will pump fluid into their wings to help them unfold. Some of this fluid will leak out of the wing and students may think they are bleeding. This is normal. The wings will dry and harden in 24 hours. The adult butterflies will not eat for at least 24 hours after emerging from the chrysalis.



Proboscis of a Butterfly

SYLLABUS EMPHASIS	ACTIVITIES	SUPPLEMENTARY INFORMATION

Problem:

What are the offspring of butterflies?

Concepts:

egg
generation
offspring
stage

Skills/Processes	**Inquiry:** Observing • Students record observations in their notebooks. **Language Arts:** Communicating Information • Students write about and discuss the behavior of adult butterflies.
Science Attitudes	A-1.32 Wanting accurate and thorough information about the natural world. • Students continue to gather meaningful information that will increase their understanding of animal life.
Science Understanding	II-A-2.4 Animals have the potential to produce numerous offspring during their adult stage. • Students note the large number of eggs laid by the butterflies and begin to wonder about the consequences should all the eggs develop.

Evaluation Strategy:

Individual, Group

Students are able to state that an adult butterfly can produce many offspring.

7. BUTTERFLY EGGS

Painted Lady Eggs

Students should continue to observe the maturing painted lady butterflies and record and illustrate observations in their notebooks.

Ask students to predict what will happen next and to record any observations that support their predictions.

Continue to allow students to investigate their own questions.

Class Discussion:

What is the next stage in the butterflies' development?

What events lead to this stage?

How do adult butterflies mate?

Do all adult butterflies lay eggs?

Where do the adult butterflies lay eggs?

How many eggs does an adult butterfly lay?

What might keep all the eggs from hatching in the classroom? In the wild?

If all eggs hatch, what will be the size of the next generation of these butterflies?

How long does it take the eggs to hatch?

What stage appears after the eggs?

How many "butterflies" constitute "all" the butterflies in the classroom?

What happens to the adult butterflies after they lay their eggs?

Materials:

Cages with adult butterflies
Potted mallow plants
Hand lenses – 12

Procedural Notes:

1) After all the adult butterflies have emerged, they will mate and lay eggs. If a potted mallow plant is placed in the cage, the butterflies will lay eggs on the mallow plant. These eggs will hatch. If no mallow plant is available, the butterflies will lay eggs on the sponge feeder stations. These eggs will not hatch. The eggs are less than 1 mm in diameter but are visible because of their pale blue color. If you wish to continue to raise butterflies, place the potted mallow plant on which eggs have been laid in an empty glass aquarium and cover with plastic wrap. Replace the mallow plant with a fresh one as soon as the original one dies or is devoured. As an alternative, place one larva each in clean culture containers to which 1 cm of culture medium has been added.

2) Students should conclude that only some butterflies (females) lay eggs and that one butterfly lays many eggs. The male and female butterflies must mate so that the eggs will be fertilized. If conditions are right, all the eggs will hatch.

SYLLABUS EMPHASIS	ACTIVITIES	SUPPLEMENTARY INFORMATION

Problem:

What are the stages in the life cycle of a butterfly?

Concepts:

adult	larva
change	life cycle
development	metamorphosis
egg	pupa
growth	stages

Skills Processes	**Inquiry:** Creating Models • A picture model can be used to depict the life cycle of the butterfly. **Language Arts:** Classifying • Students use a picture model to sequence the stages in the life cycle of the butterfly.	
Science Attitudes	A-1	Valuing the natural world and one's understanding of it. • Recognizing the vast changes that living things go through as they develop increases the students' appreciation of nature.
Science Understandings	II-A-2.1	Each generation of animals goes through changes in form from young to adult. The adult gives rise to the young of the next generation. This completed sequence of changes in form is called a *life cycle*. • Understanding of the life cycle of the butterfly is reinforced through completion of the picture model of the butterfly's life cycle.

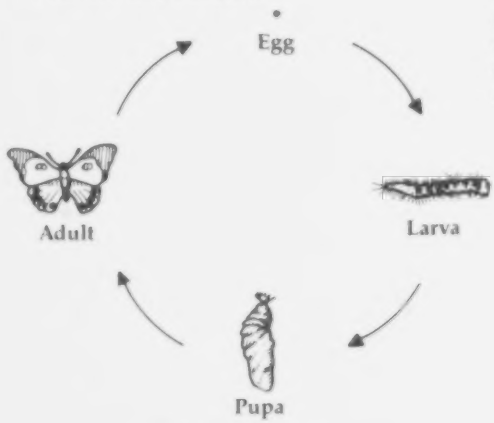
Evaluation Strategy:

Individual, Program

Students are able to identify and sequence the four stages in the life cycle of a butterfly.

8. COMPLETION OF THE LIFE CYCLE

As students continue to observe and record their observations of the butterflies and their eggs, some of the eggs will hatch into larvae. For students, this will complete the life cycle of the painted lady butterfly. At this point, students will be ready to develop a model, using drawings and pictures of the life cycle of the painted lady butterfly.



Butterfly Life Cycle

Ask students to use the observations in their notebooks to draw and label the complete life cycle of the painted lady butterfly.

Have students use the terms listed under "Concepts" in Column 1 to write a paragraph on the growth and development of the butterfly.

Class Discussion:

When is the life cycle of a butterfly completed? (Is there ever really a completion?)

What are the stages in a butterfly's life cycle?

What would it feel like to experience the life cycle of a butterfly? (See MORE IDEAS #8 for a guided imagery experience.)

What are your feelings now toward butterfly larvae, pupae, and eggs?

Why is it important to understand a butterfly's life cycle?

Why might a living thing undergo such vast changes during its life cycle?

Why are living butterflies important to us? How would you feel if there were no butterflies in the world?

Why are butterflies important to other living things? In what ways do butterflies depend on other living things? In what ways do other living things depend on butterflies?

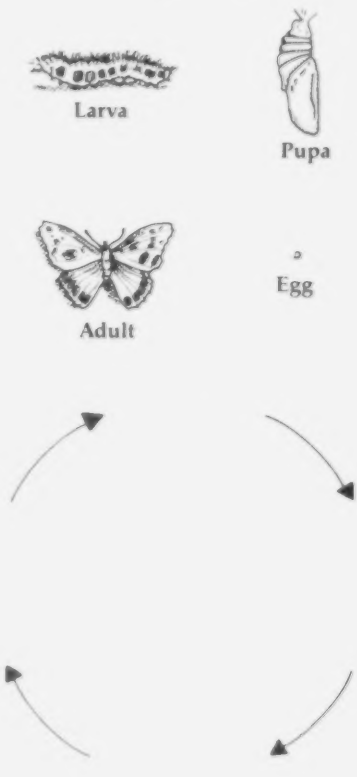
Materials:

Student notebooks and other materials from earlier activities

Procedural Note:

Use this activity as an opportunity for students to explore their feelings, attitudes, and values concerning butterflies and the various stages in their life cycles. Encourage students to express themselves orally, in writing, and dramatically. Try some of the activities in the MORE IDEAS section at the beginning of this unit.

Student Worksheet:
Butterfly Life Cycle



SYLLABUS EMPHASIS	ACTIVITIES	SUPPLEMENTARY INFORMATION

Problem:

What should be done with the butterflies when study of them is finished?

Concepts:

alternative
choice
controlled environment
natural environment
responsibility

Skills Processes	**Inquiry:** Making Decisions • Students will consider alternatives and decide what to do with the butterflies when study of them is over. **Language Arts:** Communicating Information • Students will develop a plan for what to do with the butterflies.
Science Attitudes	A-1.2 Respecting life in the natural world. • By freeing the butterflies, students show respect for this form of animal life.
Science Understandings	II-A Each kind of plant or animal continues beyond the life span of the individual because each kind is able to produce offspring. • When the butterflies are released into the natural environment, the continuation of their life cycle is ensured beyond the life span of the individual butterfly.

Evaluation Strategy:

Individual, Group, Program

Students are able to describe how they made the decision to release the butterflies by stating some of the alternative choices they considered and by stating their reason(s) for the choice made.

9. RETURNING TO THE NATURAL ENVIRONMENT

As the class nears completion of the butterfly unit, discuss with students what should be done with the butterflies when study of them is finished.

Class Discussion:

How should we "dispose of" the butterflies? What are the alternatives?

What are the consequences of each alternative? What are the values associated with each alternative and its consequences?

Which alternative is the best choice for us? Why? Could we choose several alternatives? Why or why not?

Now that we have made our choice to "dispose of" the butterflies, what is our plan for carrying it out?

Materials:

Adult butterflies, larvae, eggs, pupae

Procedural Notes:

1) As the class discusses "disposing of" the butterflies, lead them toward releasing the butterflies into the natural environment as a humane action which respects the butterflies as living organisms.

2) Make sure that students' plans for releasing the butterflies are humane. They should be released in fall or spring when the weather is and will remain mild so that the butterflies will have a chance to complete their natural life cycle.

3) *Caution*: Only *native* butterflies should be released into the environment. Both the painted lady and monarch butterflies are native to New York State, though the painted lady is not common. Be sure to discuss with students the long-term problems that could arise from releasing a nonnative species into a natural environment, such as has happened with the starling, purple loosestrife, house sparrow, house finch, gypsy moth, and many other plants and animals.

4) Some questions to use to lead students toward releasing the butterflies might include:
How long could we keep the butterflies alive in the classroom?
Will they be able to survive outdoors?
What are the differences between the controlled and natural environments?
What functions do butterflies serve in the natural environment?
Are the butterflies native to our area and should we release them if they are not?
Under what conditions should we release the butterflies into the environment?
What plan should we follow to release them?
At which stage should we release? Why?

5) Point out to students that, for many animals, it might not be appropriate to release them into the wild. Parakeets, for example, will not survive a cold winter. Some animals have never learned the skills they would need to hunt for themselves. Older animals might be frightened by new and different surroundings. And some animals, such as bears, might be drawn to people because they are used to them and have previously received food from humans.

PREPARING BUTTERFLY CAGES

When the butterfly larvae form pupae, they must be transferred to butterfly cages.

Caution: Do *not* allow pupae to remain in the larva containers. If the butterflies emerge from the pupae in the larva containers, their wings may be deformed because larva containers are too small for the emerging butterflies to extend their wings completely as they inflate them.

Use the following information to prepare butterfly cages. This may be done by the teacher, by the entire class as a preparation activity, or by a small group of students helping the teacher outside of class time.

Procedure:

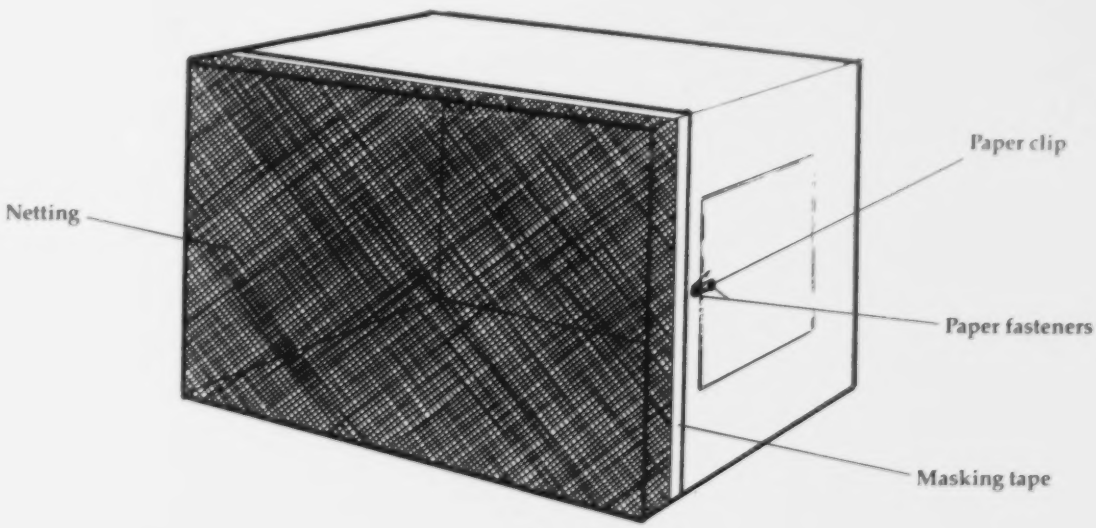
1. Draw a 15 cm x 15 cm square on the center of one side of the cardboard box to make a door for the cage. Cut through three sides of the square. The fourth side will act as a hinge. Use paper fasteners and a paper clip to make a door latch.

2. If the box still has flaps on the top where it was opened, cut them off. Then cut a piece of nylon mesh 10 cm longer and wider than the open face of the box. Tip the box so that the open face is up. Lay the nylon mesh over the opening. Use masking tape to secure the mesh to all four sides.

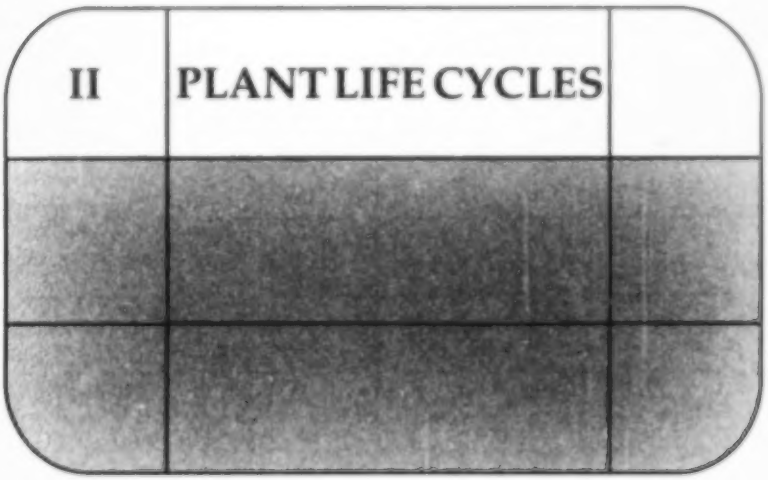
3. Tip the box as shown in the illustration. Cut a piece of construction paper to fit the bottom of the cage and place it on the floor of the cage.

Materials:

Cardboard boxes (size of duplicating paper boxes, approximately 45 x 30 x 25 cm) – 6
Netting, 6 sq. meters
Paper clips – 6
Paper fasteners – 6
Masking tape
Box knife
Scissors



Butterfly Cage


II
PLANT LIFE CYCLES

PLANT LIFE CYCLES

LEVEL II _____ (GRADE)

PROBLEM OVERVIEW

All children have seen plants growing in a pot, garden, empty lot, or field. But where did these plants come from? How did they end up along the edge of the sidewalk or in the garden? Children know that animals don't just pop up out of nowhere, but plants may seem to do just that.

It may be easy to relate the appearance of a baby animal to the existence of its parents. It is not as easy to see that plants have parents, too. Observing a plant as it goes through its life stages, including "parenthood," will help children better understand the concept of life coming from life.

SUGGESTED SCHEDULE/SYLLABUS EMPHASIS

#	Activity Title	Week 1&2	Week 3&4	Week 5&6	Week 7&8	Week 9&10	Week 11&12	Week 13&14	Week 15&16	Emphasis
1	Seeds									Observing; Classifying/Communicating Information A-1.11 Complexity, diversity, intricacy, etc. II-A-1.23 Seeds; fruits/II-A-1.31 Dispersal
2	Seed Germination									Identifying Variables/Recording Data A-1.32 Accurate information II-A-1.33 Germination, suitable conditions
3	Warmth									Identifying Variables/Questioning A-2.14 Careful, systematic investigation II-A-1.33 Germination, suitable conditions
4	Moisture									Identifying Variables/Questioning A-2.14 Careful, systematic investigation II-A-1.33 Germination, suitable conditions
5	Cold									Formulating Hypotheses/Questioning A-2.14 Careful, systematic investigation II-A-1.32 Severe conditions, temperature, drought
6	Drought									Formulating Hypotheses/Questioning A-1.32 Accurate information II-A-1.32 Severe conditions, temperature, drought
7	Flowers									Inferring/Acquiring Information A-1.11 Complexity, diversity, intricacy, etc. II-A-1.2 Flowers, seeds
8	Fruits and Seeds									Predicting/Communicating Information A-1.21 Individual life, precious II-A-1.5 Plant potential for offspring
9	The Destiny of a Seed									Creating Models/Recording Data A-1.2 Respecting life II-A-1.1 Generation, stages, life cycle
10	Plant Propagation									Manipulating Materials/Acquiring Information B-1.1 Scientific techniques, materials II-A-1.4 Other structures, offspring

SUGGESTED APPROACH

This unit allows students to study plants in more detail than in Level I, and to begin to identify and control variables in science activities. Activities in the unit can be carried out during any season of the year, as long as some advance preparation is done.

Students will be growing and observing plants in all stages of their life cycles, and they will be comparing plants with one another. As they collect seeds and attempt to germinate them, they will run into many kinds of problems. Students very naturally will ask many different "how comes," "what ifs", and "whys"; the key will be to help them translate their questions and comments into problems that can be investigated, without leaving them with a sense of frustration. For example, a discrepancy arises when seeds that are expected to germinate don't do so immediately. Since students may feel frustrated, it is important to move quickly into solving this problem: "What can I do differently to get these seeds to germinate?"

This unit will be spread out over many weeks. Seeds germinate at different rates and over different lengths of time. Activities 3-6 investigate how the variables of warmth, moisture, cold, and drought affect the germination of seeds. It is possible to select only one of these activities to carry out in depth or to carry out all four concurrently. Activities 5 and 6, however, are more difficult, and they should be attempted only if students' previous experiences with plants indicate their readiness.

Rather than trying to carry out this

unit sequentially in a specified period of time, work on it over the course of the year, coming back to it when there are observations to be made or conclusions to be drawn. Many activities can be started so that they run concurrently. Other Level II units can be started and even completed as students continue to work on this unit. Just make sure that all plants are given proper care as the unit proceeds, and don't be surprised if the classroom begins to look like a greenhouse.

It may be appropriate to have this unit culminate on Arbor Day and to plan some special events (tree planting, conservation field day, etc.).

MATERIALS

Seeds:
Bush bean, 1 packet
Lettuce, 1 packet
Tomato, 1 packet
Other, student-collected, including apple, pine, lilac, etc.
Tropical plant seeds

Fruits:
Pumpkins
Peppers
Tomatoes
Other, student-collected

White potatoes, several
Sweet potatoes, several
Bulbs, including onions

Plants:
Coleus, large-1
Tomato, 1 (or several)
Strawberry, several
Begonia

Seed heads:
Dandelion
Burdock
Sunflowers
Other, student-collected

Flowers:
Variety, with large parts, such as gladiolus, tulip, lily, daylily

Potting soil, 1 large bag

Vermiculite – 1/4 lb.

Sphagnum (peat) moss, 1 small bag

Sand, small bag

Gravel, small bag

Rooting hormone powder (Rootone), 1 packet

Centimeter rulers – 15

Plastic bags, clear, several to many per student

Planting containers:
Plastic pots, 3 inch – 12
Other, bottoms of empty milk cartons, paper cups, clear plastic bags, etc.

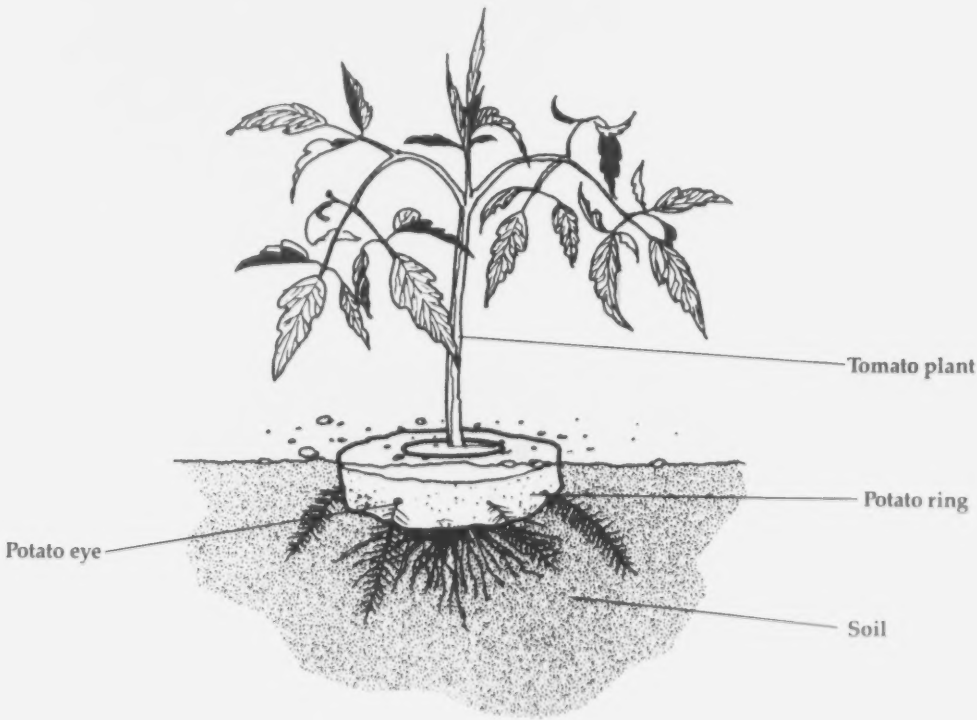
Petri dishes, large – 12
Trays, large (for drying seeds) – 5 to 10
Hand lenses – 15
Thermometer, metal-backed – 1
Paper towels
Print and nonprint resources on flowers and on plant propagation

MORE IDEAS

1. Start a calendar of natural events. This can be done in conjunction with the unit on butterflies and can include both plant and animal life. The calendar may be started at any season, but spring will provide the largest number of events to be recorded. A natural-events calendar can be continued from year to year, since many events occur with great regularity and can be predicted accurately once dates are known.
2. As an art project, make pictures and collages from a variety of different seeds. Necklaces and ornaments can also be made.
3. As a class or individual project, make a "weed patch" as a school or backyard sanctuary for wildlife. Turn over a patch of ground, then observe and record data as the wild plants take over. Observe the weed patch for at least several months, if not a year.
4. Conduct an in-depth study of one kind of plant, such as the dandelion.
5. As students collect seeds in the field, ask them to invent some devices that improve the seed-gathering process, making seed gathering more efficient or easier to carry out. Make a class display of the inventions.
6. As a class or an individual project, adopt a tree. If possible, plant a young tree, which will then belong to the class or to individual students. Take frequent field trips to observe the tree in all seasons. Closely examine tree characteristics, such as species, height, trunk, bark, leaves, buds, branching pattern, flowers, and fruit. Make drawings or take photographs of the tree over time. Ask students to write about their feelings for the tree, or to imagine that they are the tree and to write about how that feels.
7. As students collect seeds from all over, start a project to identify as many as possible of the plants from which the seeds are collected. Draw, photograph, or collect pictures of the plants and label them. Mount the results for display.

8. Grow a potato-tomato plant. Cut a seed potato into a ring, and make sure the ring has an "eye". Place a tomato plant inside the ring and plant. What happens? (Usually, only the leaves of the tomato grow. If the roots of the tomato grow through the potato ring, the plant will produce tomatoes on top and potatoes on the bottom.) (The potato plant depends on the tomato's ability to photosynthesize as the source of food for the potatoes that develop.)
9. Visit an apiary and talk with the beekeeper about the importance of bees to fruit and vegetable production.
10. Discuss with students why wildflowers should not be picked. Conduct a spring field trip to observe and identify wildflowers. Discuss rare and endangered species. Are plants included? Which ones?
11. To illustrate how plants are an essential resource for animals and humans, the following activities can be undertaken. Seeds can be set out for the birds, with observations made as to whether the seeds are eaten by birds and, if so, by which birds. Pumpkin seeds can be roasted (about 45 minutes in a 250°F oven) and shared by students as a snack. Interested students can research the extent to which seeds and nuts were an important food source for people in early America.

Potato-Tomato Plant



SYLLABUS EMPHASIS	ACTIVITIES	SUPPLEMENTARY INFORMATION

Problem:

Are all seeds the same?

Concepts:

classify
dispersal
fruit
property
seed

Skills/Processes	**Inquiry:** Observing • Seeds can be classified according to their properties. **Language Arts:** Communicating Information • By sharing information on seed properties and classification, students communicate ideas to one another.
Science Attitudes	A-1.11 Appreciating the natural world, its complexity and diversity, its lawfulness and consistency, and its intricate detail and vastness. • Marveling at the numbers and variety of seeds.
Science Understandings	II-A-1.31 Seeds have properties that aid in their dispersal. • Seeds and the fruits that encase them have many different structures that move the seeds to new locations before they germinate.

1. SEEDS

Take the class on a walk around the school grounds or to a nearby park or vacant lot. Give each student some clear plastic bags. Ask students to point out plants and their parts. Use the walk as an opportunity to review with students the understandings from Level I about plant parts and functions and plant stages of growth and development. Begin to focus on seeds by asking students to point out and collect samples of plant seeds. Make sure that 10 to 15 of each kind of seed are collected and placed in each clear plastic bag. Have students label their bags with their names and place where the seed was found (or with its source). Expand the collecting into a scavenger hunt, which can continue over several days and include seeds brought from home. When all seeds have been brought to class, begin a discussion by passing the bags of seeds around the class. As the discussion proceeds, and students are focusing on the many different types of seeds, have students begin to classify seeds according to the properties that aid in their dispersal. List these properties on the blackboard.

SEED DISPERSAL

Ways to Move Seeds	Examples
float through air	maple keys ash keys
cling to fur, clothes	burdock nettle teasel
are eaten	berries, strawberries, raspberries, blueberries, pokeberry
are buried	hickory nuts acorns
are thrown by plant	jewelweed

Materials:

For each student:

Clear plastic bags, several

For class display:

Examples of many different fruits, vegetables, and nuts
Bean seeds
Lettuce seeds
Tomato seeds

Preparation Notes:

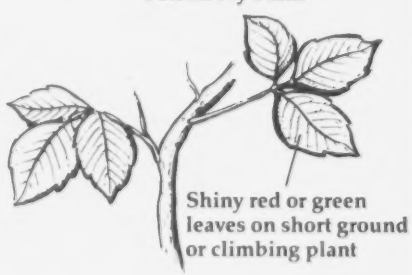
1) This activity can be performed at any time during the school year. Even when the ground is snow covered, seeds can be found above the snow on weed stalks, shrubs, and trees.

2) Make sure that the bean, lettuce, and tomato seeds to be used in the following activities are displayed and classified during this activity.

Safety Notes:

1) Before students begin to collect seeds from plants, make sure they are able to identify all parts of the poison ivy and poison sumac plants, including their berries. Do not allow students to collect poison ivy or poison sumac berries.

Poison Ivy Plant



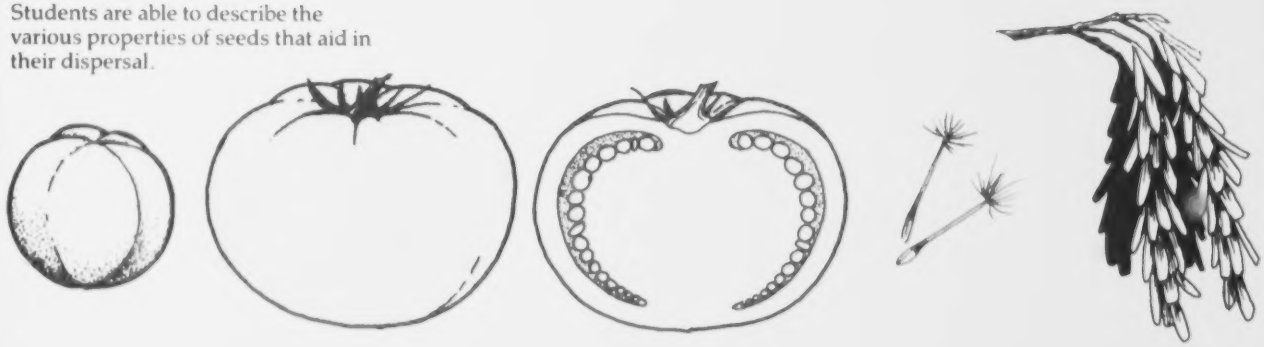
2) Garden seeds may be treated with fungicides. These seeds should not be handled directly.

SYLLABUS EMPHASIS Cont'd	ACTIVITIES Cont'd	SUPPLEMENTARY INFORMATION Cont'd
	Class Discussion: Are the seeds usually found inside another structure? How are the seeds alike? How are they different? How are fruits different from seeds? Which seeds are enclosed by fruits? How many different kinds of seeds are there? How can the seeds be classified by properties? What is the function of seeds? What usually happens to seeds? Which of the identified properties help the seeds carry out their function? How? Why must seeds be dispersed? How far can a seed go? How do fruits aid in the dispersal of seeds? How can we make these seeds grow? What conditions are necessary for germination?	**Procedural Notes:** 1) State law limits the collection of plants on State lands, and prohibits collection on all other land without the permission of the landowner. When students collect seeds at home, they should ask permission of nearby property owners, and they should not collect on public lands without permission. Even on private land where they have permission, encourage students not to collect seeds in woodlands. Most threatened or endangered plant species will be found there. The best places to collect seeds are chemically untreated lawns and fields. 2) Encourage students to bring in a variety of fruits and vegetables. Remove the seeds after the fruit has been examined by the entire class. Packets of untreated food seed and garden seed can be brought in, also. 3) Many seeds will be encased in fruits. Encourage students to make sure they are examining the seeds themselves and not just the fruits.

Evaluation Strategy:

Individual

Students are able to describe the various properties of seeds that aid in their dispersal.



SYLLABUS EMPHASIS	ACTIVITIES	SUPPLEMENTARY INFORMATION

Problem:

Do all the collected seeds germinate?

Concepts:

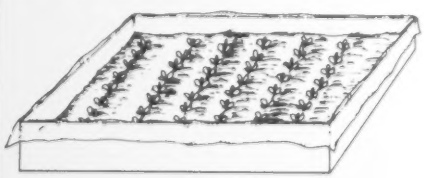
germination
method
plan
planting
seedling

Skills/Understandings	**Inquiry:** Identifying Variables • Students plant seeds and observe which ones germinate, and they tentatively identify the variables involved in germination or nongermination. **Language Arts:** Recording Data • Students collect, organize, and record information on the germination of the seeds.
Science Attitudes	A-1.32 Wanting accurate and thorough information about the natural world. • As students plan how to plant the seeds, they recognize the need for accurate information about the natural world.
Science Understandings	II-A-1.33 Seeds will germinate and produce seedlings under particular conditions of temperature and moisture. • Seeds will germinate only when conditions are right.

Evaluation Strategy:

Group

Students are able to identify tentative variables that may affect the germination of plant seeds.



2. SEED GERMINATION

After students have examined and classified their seeds, ask what they want to do with them. Encourage students to plant the seeds to see if they will germinate.

Students can plan how they are going to plant the seeds, then follow the plans. At this point, don't give students any information on proper planting of any specific seeds. There should be a variety of planting methods. Some students may plant whole fruits, others may remove seeds from fruits and plant only seeds. Moisture, temperature, light, soil, and other conditions will also vary.

Class Discussion:

Will all the seeds germinate? What is your prediction?

How will we plant the seeds? What is our plan?

What data should be collected as we observe the seeds?

How will we know when to stop the activity?

Did all the seeds germinate? How many did germinate? How many did not?

Are there similarities among the seeds that did germinate? Do seeds that did not germinate have properties in common?

Are there similarities in planting methods among the seeds that did germinate? That did not germinate?

What might have prevented certain seeds from germinating? How can we test our predictions?

Which planting methods seemed to cause seeds to germinate? How can we determine for sure the conditions necessary for seed germination?

Materials:

Seeds (from previous activity)
Potting soil
Planting containers of various kinds, such as the bottoms of empty milk cartons, paper cups, clear plastic bags, etc.

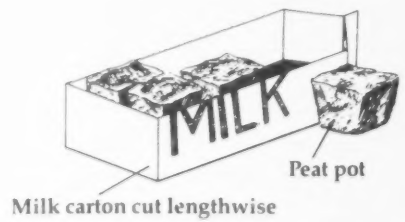
Procedural Notes:

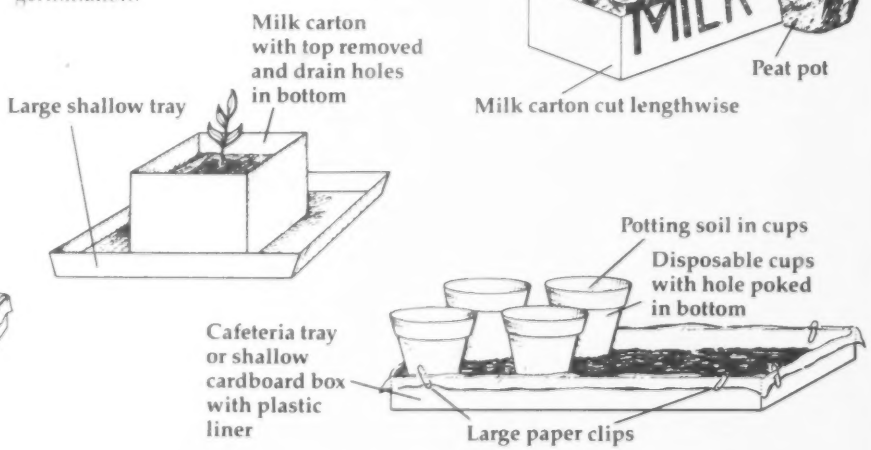
1) Make sure that the bean, lettuce, and tomato seeds from the previous activity are planted. Plant a large number of bean or other seeds (pea, lettuce) that will mature in a short time. ("Limelight" bush beans, for example, mature in 38 days.) Each student will need to observe a flowering plant in Activity 7.

2) Seeds collected from fresh fruits and vegetables may not be mature, and, therefore, may not germinate. Other seeds may not germinate either, for reasons discussed in the following activities.

3) Students may need help in recording the data from this activity. Without accurate records, the follow-up discussion will not be effective.

4) When students have completed their investigations, help them to understand that they were not engaging in controlled experimentation. Help them to sort out their data and identify for further study variables that may have affected their results.




Milk carton with top removed and drain holes in bottom
Large shallow tray
Potting soil in cups
Disposable cups with hole poked in bottom
Cafeteria tray or shallow cardboard box with plastic liner
Large paper clips

Possible Planting Containers

SYLLABUS EMPHASIS	ACTIVITIES	SUPPLEMENTARY INFORMATION

Problem:

How does temperature affect the germination of a seed?

Concepts:

conditions
control
temperature
variable

Skills/Processes	**Inquiry:** Identifying Variables • Identifying and controlling variables necessary for a properly set up experiment. **Language Arts:** Questioning • Students formulate questions for further investigation.
Science Attitudes	A-2.14 Valuing careful, systematic investigation as useful in resolving issues. • Students plan investigations carefully before beginning.
Science Understandings	II-A-1.33 Seeds will germinate and produce seedlings under particular conditions of temperature and moisture. • Most seeds germinate more quickly and are healthier when temperatures are warm.

Evaluation Strategy:

Group, Program

Students are able to plan and set up a simple controlled experiment to test how a particular environmental condition affects the germination of plant seeds.

3. WARMTH

Discuss with students their results from the previous activity. What factors seem to affect germination? Make a list of these factors. Ask the class which factors they would like to investigate further. Lead them toward investigating as a class the factors in this and the following three activities. Allow individual and groups of students to investigate other factors and problems from the previous activity which are of interest to them.

When students have identified possible factors affecting germination, ask them how they could determine positively whether or not that factor affected germination. For example, how could they determine if and how temperature affects germination.

Lead the students toward the concept of controlled experimentation for identifying the factors affecting germination. This and the following three activities investigate warmth, moisture, cold, and drought as factors affecting germination.

Class Discussion:

What is the problem? (How does temperature affect germination?)

What is our hypothesis?

How can we control our experiment?

What variable do we change on purpose? How will we change it? What variables do we keep the same? How?

How do we set up our experiment?

What data will be recorded? How will we record it?

What happened to the seeds?

What temperature conditions caused seeds to germinate faster?

Under which temperature conditions did seedlings appear healthier?

Did any seeds *not* germinate? How can we investigate this further?

What general statement can we make about the effect of temperature on germination?

Materials:

For each team of students:

Petri dishes, 3-4
Paper towels
Bean seeds, 3-4
Thermometer

Procedural Notes:

1) Students at this level will have an intuitive feel for controlling variables in a specific situation, but it is unlikely they will be able to generalize this understanding.

2) Encourage students to develop their own plans for testing how temperature affects germination. While their plans may not be rigidly controlled, their results should give them a general idea of how temperature affects germination. Discussion can often identify where errors were made in controlling their experiments.

3) A typical student plan might look like the following:

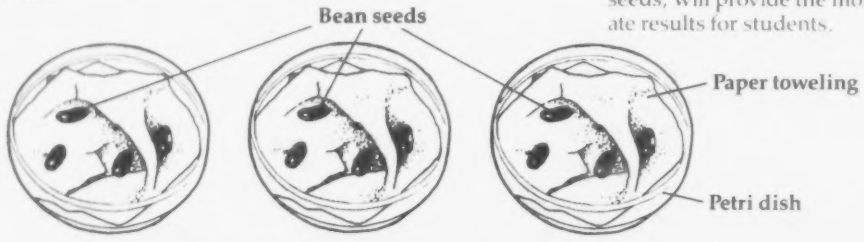
a. Place paper toweling on the bottom of petri dishes. Moisten the toweling in each dish with the same amount of water and place 3 to 4 bean seeds in each dish.

b. Place one dish in a refrigerator, one at room temperature, and a third at about 86°F (30°C).

c. Look at the seeds every day. Observe and record the observations.

Light is also a variable here. If the students notice, then a discussion can follow. How can the experiment be conducted so that light is not a variable?

4) An important variable to control is the seed itself. The same kind of seed should be used across all parts of each experiment. Be sure that students are using seeds that are ready to germinate, such as beans, tomatoes, peas, peppers, lettuce, etc. Seeds with short germination times, such as bean seeds, will provide the most immediate results for students.



SYLLABUS EMPHASIS	ACTIVITIES	SUPPLEMENTARY INFORMATION

Problem:

How does moisture affect the germination of a seed?

Concepts:

conditions
control
moisture
variable

Skills/Processes	**Inquiry:** Identifying Variables • Identifying and controlling variables necessary for a properly set up experiment. **Language Arts:** Questioning • Students formulate questions for further investigation.
Science Attitudes	A-2.14 Valuing careful, systematic investigation as useful in resolving issues. • Students plan investigations carefully before beginning.
Science Understandings	II-A-1.33 Seeds will germinate and produce seedlings under particular conditions of temperature and moisture. • Seeds require some moisture for germination. Too much moisture will result in less healthy plants.

Evaluation Strategy:

Group, Program

Students are able to plan and set up a simple controlled experiment to test how a particular environmental condition affects the germination of plant seeds.

4. MOISTURE

Discuss with students how they think moisture affects the germination of seeds. Ask them to make a hypothesis, then to develop and carry out a plan to test that hypothesis.

Class Discussion:

In general, class discussion should center on the questions from the previous activity. Specific questions pertaining to how moisture affects germination might include:

What general statement can we make about the effect of moisture on seed germination?

What general statement can we make about how the lack of moisture affects the germination of seeds?

What unexpected results did you obtain? Do we want to investigate these further? What is our problem?

Materials:

For each team of students:

Petri dishes or plastic bags, 3
Paper towels
Bean seeds, 4
Other seeds

Procedural Notes:

1) Always lead students toward the concept of controlled experimentation, as they continue to develop and carry out their own plans. As students work through these activities, their ability to identify variables and control experiments should increase. Allow students to make mistakes; they will learn from their mistakes as they proceed. An experiment on moisture, for example, can be refined and redone several times, as students discover where they went wrong.

2) A typical student plan for investigating moisture may look like the following:

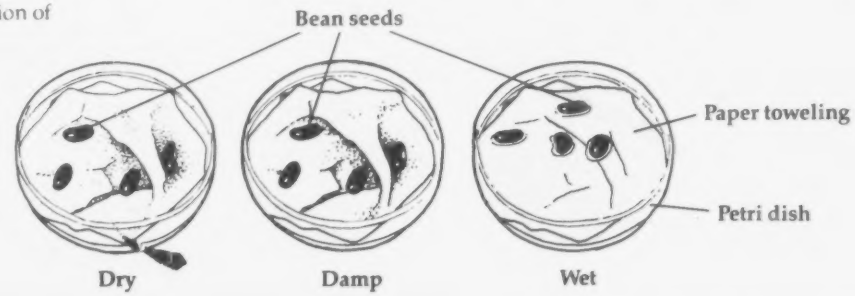
a. Place paper toweling on the bottom of the petri dishes. Put several (at least 4) seeds on the toweling.

b. One petri dish is left dry; the paper toweling in the second is moistened. Let the seeds float in the water in the third petri dish.

c. Cover the dishes and put them on a windowsill. Keep temperature and light the same for all seeds.

d. Observe the dishes each day and record the observations.

3) Besides temperature and moisture, students will have listed other factors which affect germination. Most common among these will be light and soil. If interest among students is high, allow them to plan and carry out controlled experiments to test these factors. Be sure they test different kinds of seeds. They, and you, might be surprised at the results.



SYLLABUS EMPHASIS	ACTIVITIES	SUPPLEMENTARY INFORMATION

Problem:

How does cold affect seeds?

Concepts:

cold
controlled experiment
hypothesis
severe conditions
survival
variable

Skills/Processes	**Inquiry:** Formulating Hypotheses • Students plan and carry out experiments on the effect of cold on the germination of seeds. **Language Arts:** Questioning • Students formulate questions and hypotheses for further investigation.
Science Attitudes	A-2.14 Valuing careful, systematic investigation as useful in resolving issues. • Sometimes properly set up experiments take a long time before results can be observed.
Science Understandings	II-A-1.32 Some seeds may be able to withstand severe conditions including cold winters and drought. • Some seeds not only withstand severe cold, they actually require a period of cold before they will germinate.

5. COLD (OPTIONAL)

Discuss with students their results from the second activity. Point out that while warmth and moisture were necessary for seeds to germinate, some seeds still did not germinate. Ask students to brainstorm possible reasons why these seeds did not germinate. While all possible reasons can become a topic for investigation, discuss the possibility that a period of cold may be necessary before some seeds will germinate. Did some planted seeds not germinate because they did not undergo a period of cold?

Ask students how they could determine whether some seeds need a period of cold before they will germinate. Allow them to plan and carry out their controlled experiments as in the previous two activities.

A closely related question is whether seeds which do not need cold before germination can survive cold conditions. Lead students towards formulating this question and planning and carrying out controlled experiments to test their hypotheses. Many different kinds of seeds should be tested.

Class Discussion:

Why do you think some of the seeds from previous activities didn't germinate even when temperature and moisture conditions seemed right?

Which seeds might require a period of cold before they will germinate? How could you test this?

How long should the seeds be subjected to cold?

Which seeds seem to require a period of cold before they will germinate? Why might these seeds require this cold period?

Are some packaged garden seeds prepared for planting by being subjected to a period of cold? Write to a seed company for the answer to this question. Which seeds? How long a cold period?

Can seeds which don't require a period of cold before germination *survive* periods of cold? How could we test this? How will we know when we have subjected the seeds to a long enough period of cold?

Materials:

Clear plastic bags or other containers for refrigerating and germinating seeds, several to many
Seeds collected by students, including maple, apple, pine, and lilac seeds
Tender seeds, such as beans, peas, etc.
Vermiculite or peat moss
Paper punch
Marking pen

Preparation Notes:

1) Attempt this activity only if students' previous experiences with plants indicate readiness and if student interest is high.

2) Large numbers of seeds must be collected for this activity. Maple seeds should be collected by the teacher or students in spring. Pine seeds can be collected from cones whenever they open. Lilac seeds can be collected in late spring and summer, apple seeds in fall.

3) The seeds of many plants that occur naturally in New York State must be subjected to a period of cold before they will germinate. This is a survival adaptation, ensuring that seeds will not germinate in the fall just before adverse winter conditions that would kill tender, young plants. In many of these "cold-requiring" species, chemicals that inhibit growth occur within the seed. During the period of cold that these seeds are normally subjected to in the environment, the level of growth-inhibiting chemicals decreases, while the level of growth-promoting chemicals increases.

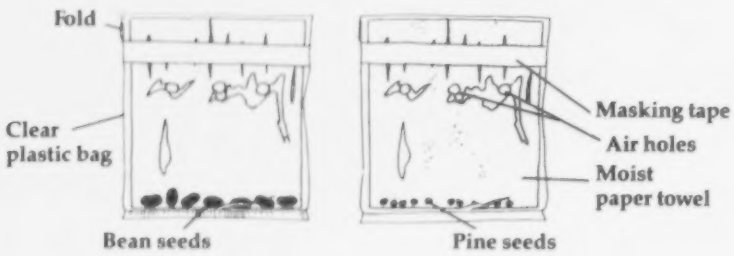
4) To simulate a cold period, seeds can be treated in the following manner:

a. Soak seeds in water for 24 hours or more.

b. Punch 2 or 3 air holes at the top of each plastic bag the seeds will be placed in.

c. Place about a cup of damp (not wet) vermiculite or peat moss in each plastic bag, then place 50-100 seeds (depending on size) in each bag. Mark each bag with kind and number of seeds inside.

SYLLABUS EMPHASIS Cont'd	ACTIVITIES Cont'd	SUPPLEMENTARY INFORMATION Cont'd



Evaluation Strategy:

Group

- Students are able to identify variables and formulate hypotheses that lead to simple controlled experiments on factors that affect seed germination.

d. Place the bags in the freezer for 2-3 days.

e. Refrigerate the seeds at about 1-10° C (33-50° F) for 2 to 3 months.

f. At weekly or biweekly intervals, remove about 10 of each kind of seed and plant to see how many germinate. Record results, perhaps on a large wall graph.

Alternatively, seeds can be placed outdoors over the winter. Put seeds and damp vermiculite or peat moss into coffee cans that have already been punched with air holes, then bury the cans in the ground. (The cans prevent rodents from eating the seeds.)

5) While it is preferable to have students carry out this activity from beginning to end, seeds can be prepared ahead of time by the teacher so that they are ready to plant when this activity takes place.

Procedural Notes:

1) Make sure tender seeds that will not survive cold are subjected to cold conditions also.

2) If results are graphed over time, students should find that the number of tender seeds that germinate will decrease, while the number of "cold-requiring" seeds that germinate will increase and reach a peak or plateau at some point in time. For example, apple seeds kept at 4°C (40°F) showed a 10 percent germination rate after 10 days, a 75 percent germination rate after 40 days, and a 100 percent germination rate after 68 days.

3) Do not germinate seeds at temperatures above about 70°F (21°C). When subjected to high germination temperatures, some seeds that have gone through a cold period become dormant again and must be resubjected to a cold period.

4) Most cultivated seeds do not require a period of cold before germination since a cold requirement is not a desirable trait and growers have selected seed varieties without this trait. It is interesting to note that many cultivated varieties cannot survive without humans to protect their seeds.

5) Some seeds, such as peaches and cherries, require a period of cold only if they are allowed to dry. If planted immediately upon maturity of the fruit, they will germinate.

SYLLABUS EMPHASIS	ACTIVITIES	SUPPLEMENTARY INFORMATION

Problem:

How does drought affect the germination of seeds?

Concepts:

controlled experiment
drought
hypothesis
properties
severe conditions
survival
variable

Skills/Processes	**Inquiry:** Formulating Hypotheses • Students plan and carry out experiments on the effect of drought on the germination of seeds. **Language Arts:** Questioning • Students formulate questions and hypotheses for further investigation.
Science Attitudes	A-1.32 Wanting accurate and thorough information about the natural world. • Students recognize the importance of careful planning to obtain accurate information.
Science Understandings	II-A-1.32 Some seeds may be able to withstand severe conditions including cold winters and drought. • While many seeds cannot withstand drought, many other seeds can withstand drought and still germinate.

Evaluation Strategy:

Group, Program

Students are able to plan carefully and carry out a simple controlled experiment on seed germination.

6. DROUGHT (OPTIONAL)

Following the discussion from the previous activity about conditions that seeds can survive, ask students to brainstorm other severe conditions that they would like to test to see if seeds can survive them. Drought is a condition that is likely to be mentioned, especially if students are thinking of plants that survive in the desert.

Allow students some time to examine different kinds of seeds. Based on the properties they observe, can students predict which seeds will survive drought and which seeds will not?

Ask students to devise a controlled experiment that would determine which plant seeds could survive drought conditions. Have them plan and carry out their experiments.

If students have other severe conditions they'd like to test, allow them to plan their experiments, but make sure they have teacher approval before they begin.

Class discussion:

Can seeds survive conditions of drought? How can you test this?

How long should the seeds be subjected to drought? How will we know when we have subjected the seeds to a long enough period of drought?

When did you decide to end your experiment? Why?

Which seeds cannot survive drought?

Which seeds can survive the drought you subjected them to? How long a drought do you think these seeds could survive? Go to the library and research how long different kinds of seeds have been known to survive and still germinate. What seems to be the record?

What properties of the seeds seemed to help them survive drought? How did these properties help them survive?

Materials:

Many different kinds of seeds, including tender seeds, tropical plant seeds, and seeds that have already been subjected to their required cold period
Clear plastic bags or other containers for germinating seeds, several to many
Trays for drying seeds, several

Preparation Notes:

1) Attempt this activity only if students' previous experiences with plants indicate readiness and if student interest is high.

2) Use some tropical plant seeds in this activity, since many of these seeds cannot withstand drying.

3) Some cactus seeds would be interesting for students to test. These are available from seed catalogs.

Procedural Notes:

1) Students will be working on this activity in much the same way as they have worked on the previous activities. They will need to determine how long seeds should be dried before it can be said they have survived drought conditions. Like the previous activity, this activity will take a fairly long period of time. It is not necessary to try to maintain student interest over this long period. They will naturally become excited again whenever it is time to observe their results.

2) A typical student plan may look like the following:

a. Place many different kinds of seeds on trays and place the trays on a windowsill where they will get as much sun as possible. (An alternative would be to place the seeds under a 100-watt light bulb that is kept on all the time.)

b. On the first day, and then every week or two, remove about 10 of each kind of seed and test them to see if they still germinate. Compare the numbers that germinate from each kind of seed over time. Graph results (perhaps on a large wall chart).

SYLLABUS EMPHASIS	ACTIVITIES	SUPPLEMENTARY INFORMATION

Problem:

How do plants produce seeds?

Concepts:

flower
infer
odor
pistil
pollen
pollination
stamen

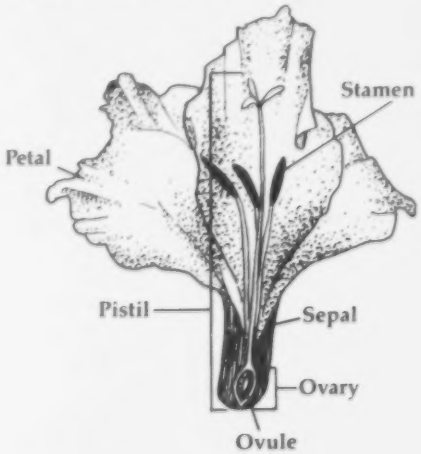
Skills/Processes	**Inquiry:** Inferring • Students infer the functions of flower structures. **Language Arts:** Acquiring Information • As students check their inferences against reference materials, they gain new information about plants and their flower structures.
Science Attitudes	A-1.11 Appreciating the natural world, its complexity and diversity, its lawfulness and consistency, and its intricate detail and vastness. • Students marvel at the beauty and intricacy of flowers.
Science Understandings	II-A-1.2 The flower is the structure in mature flowering plants that enables offspring to be produced in the form of seeds. • Flowers have structures that aid in the formation of plant offspring.

7. FLOWERS

Bean Plant in Flower

Use the bean or pea plants that were germinated in the second activity and that have continued to grow. As students observe the growth of these plants and relate it to what they observed if they grew plants in a Level I activity, ask them what they think will next happen to the plants.

Have students continue to observe the plants and record any changes that occur over time. After several weeks, the plants will flower. Most students will have had some experiences with flowers and have a general idea of their function, but many students will not have examined flowers carefully. Encourage them to observe the flowers carefully, and make several different kinds of flowers available to them for observation. Encourage drawings, diagrams, and three-dimensional paper models of their observations.



Typical Flower Structures

Materials:

For each team of students:
Bean or other plant that matures in a short time (from first activity)
Large flowers, such as tulip, gladiolus, lily, and daylily, that are easy to take apart (these are readily available from florists, and you may be able to obtain free flowers about to be discarded), several
Hand lens
Print and nonprint resources on flowers

Preparation Notes:

1) Make sure that you have enough bean plants growing from the first activity for each student team to have one to observe.

2) Be careful about collecting flowers from plants growing wild outdoors (see the first activity). Woodland flowers in particular may be from rare or endangered species.

Safety Note:

If students are observing flowers outdoors, caution them to avoid bees and other stinging insects. Check to see if any students are allergic to bee stings.

Procedural Notes:

1) As students examine the flowers, encourage them to dissect the flowers carefully. Petals can be pulled from flowers, and the pistil, stamen, and ovary can be examined more closely. Make sure that students see the pollen and make an inference as to its function.

2) Ask students whether trees flower. How could they find out? Ask students to present evidence that they do or do not flower. What about grasses?

3) Arrange a trip to an orchard, preferably when the trees are in full bloom. If the orchard can be visited several times, have students keep a log of their trips.

4) Students may be interested in finding out what the State flower (rose) is. Reports about the State flower can be written or a project undertaken to grow plants of the State flower and give them away as gifts.

SYLLABUS EMPHASIS Cont'd	ACTIVITIES Cont'd	SUPPLEMENTARY INFORMATION Cont'd
	Provide hand lenses for close observation. As students express interest and curiosity, encourage them to infer the function of the various structures they see. Provide reference texts for them to look up flower parts. Toward the end of the activity, provide a flower structure reference sheet, and a worksheet based on a typical flower for them to fill out. If the season is appropriate, take students out to a local garden or patch of flowers. Ask them to sit quietly and observe the flowers from a distance. What do they see? Are there any birds or insects visiting the flowers? Ask the students to move closer to the flowers and record any new observations. Then ask each student to move to within a foot or two of a flower and observe again. Finally, ask them to observe the flower as closely as possible without picking it. What do they see? What kind of animal life do they find on the flower? Do these animals seem to serve any function that helps the flower? **Class Discussion:** What did you predict would happen to the plants as they grew? Did this happen? What do flowers look like? What is their function? What are some of the structures found in flowers? What are their functions? How are flowers from different kinds of plants different from one another? What structures do all flowers seem to have? Did the flowers you've studied have any odor? What might be the function of odor in flowers? What color were the flowers you've studied? What function in flowers might color serve? Why are flowers important to people? To other animals?	5) Students might write stories or poems about their feelings toward flowers or dramatize what it might feel like to be a flower. 6) Students might be interested in undertaking a beautification project, such as planting a flower garden on the school grounds or in a neighborhood location.
Evaluation Strategy: Individual, Group Students are able to describe flowers and the functions of their major parts.		

SYLLABUS EMPHASIS	ACTIVITIES	SUPPLEMENTARY INFORMATION

Problem:

How many seeds will grow into adult plants?

Concepts:

population
potential for offspring
survival

Skills Processes	**Inquiry:** Predicting • Students predict what might happen if all the seeds produced by a fruit germinated and grew into adult plants. **Language Arts:** Communicating Information • Students share their ideas about what might happen when large numbers of a single kind of plant germinate.
Science Attitudes	A-1.21 Respecting each individual life as precious to the individual and others. • When students realize that not all seeds can germinate and survive to adulthood, the lives of individual plants, especially mature plants, become more precious to them.
Science Understandings	II-A-1.5 Plants have the potential to produce numerous offspring. • Many fruits produce large numbers of seeds, of which only a few can survive under natural conditions to become adult plants.

8. FRUITS AND SEEDS

Pepper Fruit Containing Seeds

Plan another collecting trip or scavenger hunt with students, this time to collect various fruits which are likely to be full of seeds. As students collect and examine the fruits, lead them toward the question of how many seeds each kind of fruit produces. Back in the classroom, allow students to open the fruits carefully, remove the seeds, and count them. Help them to plan a data table for recording the numbers they get.

Fruit	Number of Seeds	Number which Germinated	Number which Grew Large and Healthy
Pepper			
Pumpkin			
Tomato			
Sunflower head			
Dandelion			
Burdock			
Pine cone			

As students marvel at the large numbers of seeds some fruits produce, they may also wonder what would happen if all the seeds germinated and grew into adult plants. Encourage them to plan an experiment which would demonstrate what might happen.

Class Discussion:

Which fruits did you think would produce a large number of seeds? Which actually did? Which fruit produced the largest number of seeds?

What would happen if all the seeds from one fruit or one plant germinated? What investigation could you carry out to demonstrate this?

How many seeds germinated? How many seeds grew into healthy, adult plants? What were your observations as you watched the plants grow?

Materials:

Fruits of many different plants, including pumpkins, peppers, and tomatoes (as available seasonally)

Complete seed heads of dandelions, burdock, sunflowers, and other plants that produce large numbers of seeds

Planting containers, clear plastic bags for germination, or paper towels and plastic wrap

Clear plastic bags for collecting seeds

Preparation Note:

Have fruits and seed heads available ahead of time if outside conditions are not appropriate for collecting fruits and seeds. Dandelion seed heads can be collected in spring, burdock and sunflower in fall. You may want to plant some sunflowers in a home garden in spring to have the seed heads on hand for the following year's unit.

Safety Note:

Before students begin to collect plant seeds, make sure they are able to identify all parts of the poison ivy and poison sumac plants, including their berries. Do not allow students to collect poison ivy or poison sumac berries.

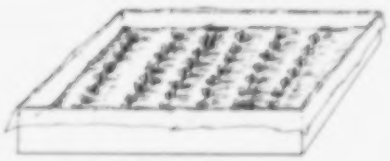
Procedural Notes:

1) If students are collecting fruits themselves, make sure they get delicate seed heads back to the classroom intact. Plastic bags, for example, would be good for carrying dandelion seed heads.

2) Student plans to illustrate the potential for offspring might include any of the following:

a. spreading all the seeds from a single dandelion head on moist paper towel, placing the towel in a clear plastic bag, and observing how many germinate.

b. planting all the seeds from a burdock in one small planting container, then observing the results.

SYLLABUS EMPHASIS Cont'd	ACTIVITIES Cont'd	SUPPLEMENTARY INFORMATION Cont'd
	If the plants began to appear sickly, did you have any ideas for how to help them? How might disease affect the number of plants growing close together? What would happen if all seeds germinated and grew into adult plants? In nature, what happens to most seeds and to many plants? Why are seeds and plants important to animals? To humans?	 c. planting all the seeds from a pumpkin in a 30 x 30 cm garden plot, then observing the results. Of course, all plans must include proper care of plants. If students express concern about the plants growing too close together for all of them (or even any of them) to survive, encourage students to develop a plan for helping the plants. They will have attained the concept of potential for many offspring by this time, and a plan to help the plants will show respect for the lives of individual plants. This plan is likely to include transplanting the plant to its own container or to a location on the school or home grounds. 3) Help students to realize that plants are the food source for animals and that the potential for many offspring is a mechanism for assuring the continuation of a species, given that many plants are likely to be eaten. Discuss with students how plants are used by animals.

Evaluation Strategy:

Individual

Students are able to demonstrate concern for individual living plants by caring for cultivated plants or by not destroying wild plant life without justifiable reasons.

SYLLABUS EMPHASIS	ACTIVITIES	SUPPLEMENTARY INFORMATION

Problem:

What happens to the seeds plants produce?

Concepts:

fruit
life cycle
seed

Skills/Processes	**Inquiry:** Creating Models • Students develop a model of the life cycle of a plant. **Language Arts:** Recording Data • Students record observations as seeds and fruits develop on their plants.
Science Attitudes	A-1.2 Respecting life in the natural world. • By planting some of the seeds, even though they may use the other seeds in different ways, students are treating plants as living things whose life is to be respected.
Science Understandings	II-A-1.1 Each generation of flowering plants goes through changes from seed to mature plant. The mature plant gives rise to the seeds of the next generation. This completed sequence of changes in form is called a life cycle. • The development of fruits and seeds from flowers completes the life cycle of a plant.

Evaluation Strategy:

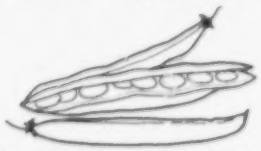
Individual

Students are able to make a model of and describe the life cycle of a plant.

9. THE DESTINY OF A SEED

Students should continue to observe the flowers on the plants they've grown from seed. Observations should be made daily, and diagrams, measurements, and other records made of the observations.

As the flowers develop into fruits, students should be observing how this occurs. Lead them toward the question of what to do with the fruits and the seeds inside them. Students may suggest several possibilities: eating the beans (or whatever fruit they're examining) raw to see how they taste or perhaps cooking and eating them, opening the pods to observe the seeds, taking the seeds out and dissecting them to see what structures they contain, or counting the number of seeds produced by one plant. As the students engage in these activities, encourage them also to plant some seeds to see if they will grow. In this way, they will experience a plant life cycle from germinating seed to germinating seed and realize that a seed comes from a parent plant.



Bean Pod Containing Seeds

As a culminating experience for this activity, ask students to draw or otherwise create a model of a plant life cycle. Scrambled drawings could be handed out for students to sequence and label correctly.

Class Discussion:

What happened to the flowers? From what part of the flower does the fruit develop? What happens to other flower parts as the fruit develops?

How can you graph the growth of a fruit? What does this graph of the growth of the fruit show?

What do the fruits look like? Where are the seeds? What do the seeds look like? Do they look the same as the seeds that you originally planted?

Will the seeds grow? What is your plan to grow them? What will the seeds produce?

What are some of the ways people or animals use the seeds from the plants you've grown?

What is the life cycle of a plant? How can you observe this life cycle for other plants? Draw the life cycles of several different kinds of plants, such as trees, grasses, or wildflowers.

What happens to your plant after it has fruited?

Materials:

Plants from previous activity
Hand lenses
Centimeter rulers – 15

Bean Plant with Fruits Containing Seeds

Procedural Notes:

1) Make sure other plants that are flowering and fruiting are also available to students so that they can observe their life cycles. Take walks around the school grounds or to a nearby vacant lot or park and ask students to identify the stages in the life cycles of other plants.

2) If a unit on butterflies has been completed, ask students to compare a butterfly life cycle to a plant life cycle. How are they similar? How are they different?

SYLLABUS EMPHASIS	ACTIVITIES	SUPPLEMENTARY INFORMATION

Problem:

How can plants complete their life cycle without forming seeds?

Concepts:

bulbs
cuttings
production of offspring
runners
tubers
vegetative propagation

Skills/Processes	**Inquiry:** Manipulating Materials • Students carry out investigations to show how plants can be propagated. **Language Arts:** Acquiring Information • Students do library research and question adults about how to propagate plants, then record data as they carry out their own propagation investigations.
Science Attitudes	B-1.1 Enjoying working with living and nonliving materials and with scientific techniques or having a high regard for those who do. • Students will enjoy investigating methods of propagating plants.
Science Understandings	II-A-1.4 Structures other than flowers enable offspring to be produced in some plants. • Runners, tubers, cuttings, and bulbs are all methods by which plants complete their life cycles.

Evaluation Strategy:

Individual, Group

Students are able to demonstrate methods of plant propagation and to produce new plants by propagation.

10. PLANT PROPAGATION

Ask students if they think there are other ways in which some plants complete their life cycle without seed formation and seed germination. If students cannot come up with any ideas, send them on a "research" hunt to see how many ways they can find to grow a new plant without starting a seed. Besides engaging in library research, students should be encouraged to seek out and talk to orchardists, farmers, florists, garden club members, and others who may have information.

As students gather information, help them to plan investigations to observe these other methods of completing the plant life cycle.

Ask students to devise and keep a data table showing all their investigations and the results. A summary chart such as the one shown can be used for display.

Plant	Method	Plant Part
strawberry potato begonia raspberry onion apple cattail tulip	layering	runner

Class Discussion:

What are some of the ways plants can reproduce themselves without starting from seed?

What plants can be propagated each way?

What ways to start cuttings are better than others? How about tubers? Runners? Bulbs?

What happens when a cutting is planted?

Which plants develop best from cuttings? In what planting material do cuttings seem to do best?

What effect does rooting hormone powder have on the development of cuttings? How can you find out?

Which of the different methods of completing life cycles are important to plants? Why?

In what ways do people use these methods of growing new plants? Why?

Materials:

Vermiculite
Sphagnum moss
Gravel
Rooting hormone powder
Planting containers
Plants, including coleus or begonias, tomatoes, strawberries, potatoes, sweet potatoes, and onions
Bulbs
Sand
Potting soil
Print and nonprint resources on plant propagation

Preparation Notes:

1) Obtain bulbs well ahead of time. Other plants also should be obtained ahead of time or students can bring them in as part of their search.

2) For specific information on plant propagation, see the appendix at the end of this activity.

3) Alert the librarian that students will be researching plant propagation methods.

Procedural Notes:

1) Encourage students to try to propagate several kinds of plants. When they have a plant they want to know about, let them try to propagate it. Pineapple, carrot, beet, parsnip, radish, and turnip tops will grow when placed in water.

Many plants will propagate from cuttings, but some "slip" more easily than others. Coleus, begonias, petunias, and geraniums will all root easily.

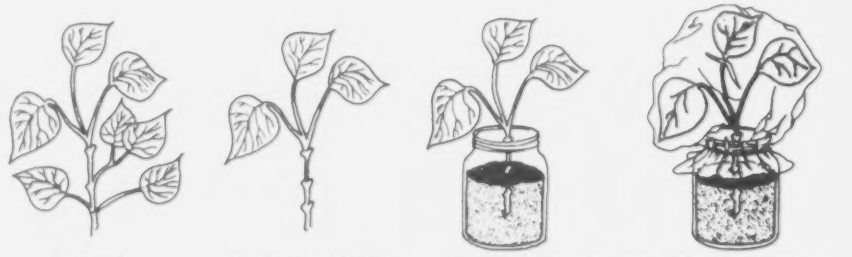
Some plants, such as the strawberry begonia and spider plant, grow new plants which hang from the ends of runners. These can be displayed to students, and new plants can be grown from the plantlets. These plants, or Christmas cacti or pussy willows grown from cuttings, can be grown as a class project and given away by students as holiday gifts.

2) Encourage students to try out new propagation techniques and to compare techniques to one another. This will require students to plan simple controlled experiments. Some questions they might raise include: Does rooting powder speed root formation? For a given plant, does soil, water, sand, sphagnum moss, or vermiculite work best? How do raspberry bushes propagate?

HINTS ON PROPAGATING PLANTS

Preparing cuttings:

Choose compact growth that is not "leggy." Count about 5 nodes down from the tip of the shoot and make a diagonal cut just below a node. Remove the lower leaves, leaving only 2-3 leaves at the top. Dip the cut end in rooting hormone powder, and insert the cutting in moistened sand or vermiculite, or place the cutting in a glass of water. To retain moisture, the cutting can be covered with plastic, but the plastic should not touch the leaves. Keep the cutting out of direct sunlight for a few days. When strong root growth is evident, transplant the cutting to potting soil.



a. Cutting

b. Cutting With All But Three Leaves Removed

c. Cutting Placed in Container of Water

d. Plastic Covering Cutting and Container

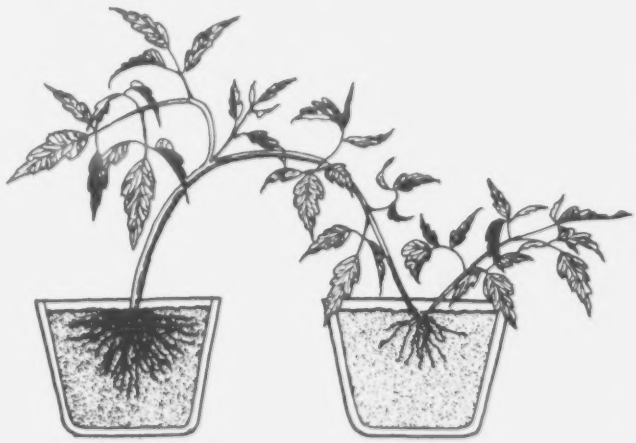
Stem Cutting

Preparing tubers:

Cut a potato into several pieces so that each piece has a bud or "eye." (If students don't check for buds first, the differences in the growth of the pieces will pose an interesting discrepancy). Plant each piece in potting soil.

An alternative is to place a whole potato in a container of water so that it is partially submersed (toothpicks may be needed for suspension). Keep the plants in the dark for a few days as roots form, then move to light. Transplant to potting soil when strong growth is evident. (Sweet potatoes, which are roots rather than tubers, can be grown in much the same way.)

Potato in Water



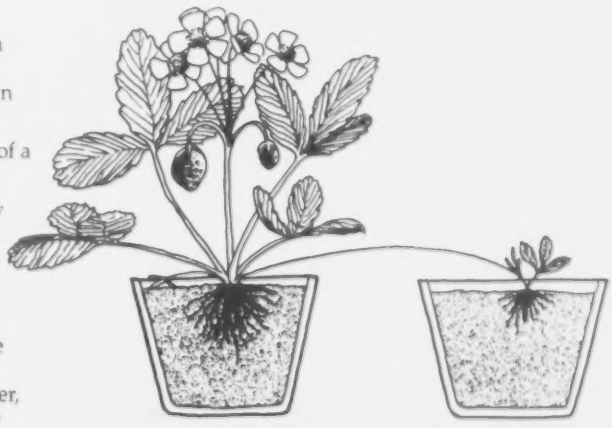
Tomato Layering

Layering:

For tomato plants, bury a stem, without cutting it from the plant, in potting soil, sand, or vermiculite. Large hairpins or lengths of wire can be used to hold the stem.

For strawberry plants, bury the tip of a runner directly in another pot.

Once new plants have formed, they can be separated from the parent plant.



Strawberry Layering

Preparing bulbs:

Obtain bulbs at least 8 weeks before they will be needed for the activity. Arrange them in a planting container, tips up, and cover them with soil or bulb fiber so that only the tips are visible. Refrigerate or store in a dark, cold (40-50° F) location for 6-8 weeks, then place in a cool, sunny location.

GROWING TIPS

1. Most important! Expose your plants to sunlight as much as possible. The plants should be on the window sill all day long. Plants should not touch the window glass. A window with southern exposure is best. Perhaps you can place your plants in another room periodically if your windows do not face south.
2. Too much water will cause seeds to rot. If mold develops, decrease amount of water. Do not over-water the plants. Yellow leaves or brown stems indicate over-watering.
3. Do not allow the plants to dry out. Keep them at least one foot away from the hot-air ventilator. Brown leaves indicate dry air damage.
4. Do not allow the plants to become too cold. It may be necessary to remove the plants from the window sill at night and over the weekends.
5. Over vacations make arrangements for plant care with your custodian. Sending young plants home is not recommended since they are tender and tend to break in transit. Mature plants should be sent home at the *end* of the school year. (See How To Care For Classroom Plants Over Vacations, below.)
6. Do not plant seeds too close together, particularly beans and peas.
7. Use planter sticks to help hold up tall plants. Use twisters from bread wrappers to hold plants to planter sticks.
8. Plant seeds twice as deep as the seed's diameter.

FIGURE 1

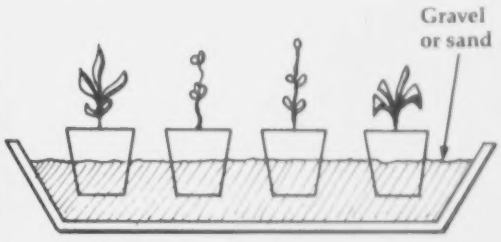
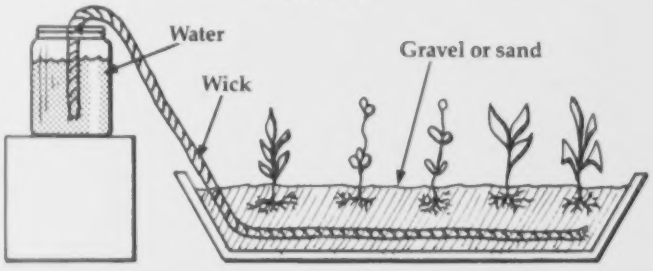


FIGURE 2



HOW TO CARE FOR CLASSROOM PLANTS OVER VACATIONS

Everyone likes school vacation except classroom plants.

The two most important factors in caring for classroom plants during school vacation times are adequate light and the proper amount of water. Place your plants in a location where they will receive adequate light. Listed below are four methods for keeping them properly watered.

1. For small individual planters such as milk cartons, paper cups, and plastic cups with holes in the bottom, partially bury them in a large tray with small stones or sand to a depth of 6 cm. Add 3 cm of water. (See figure 1.)
2. For class gardens use a wick of cotton clothesline run under the potting soil to a jar filled with water. Cover the jar with a lid or plastic wrap to cut down on evaporation. (See figure 2.)
3. For large individual planters, cut and bend coat hangers or other wire into arches to fit the individual planters. Water and cover with a plastic bag. (See figure 3.)
4. For class gardens, cut and bend coat hangers or other wire into arches and place in box at both ends, parallel to each other. Water and cover with a large plastic bag or clear plastic sheeting. (See figure 4.)

FIGURE 3

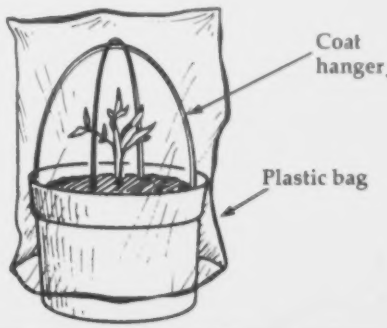
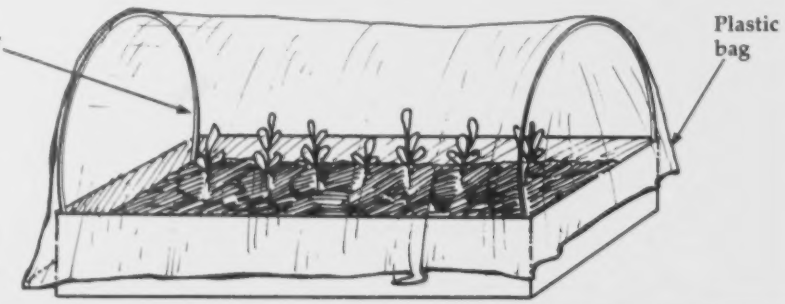
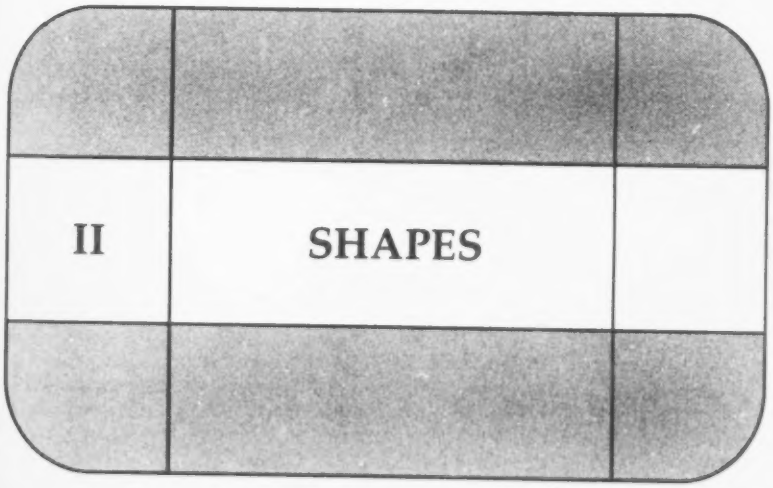


FIGURE 4




II
SHAPES

SHAPES

LEVEL II _____ (GRADE)

PROBLEM OVERVIEW

Children may have good ideas about the properties of the paper they write on and play with every day. Most children have made and flown paper airplanes. Only a few children, though, will have thought about the differences between the properties of a piece of writing paper and a paper airplane, both made of the same kind of paper.

By engaging in the activities in this mini-unit, students will question their preconceptions about common objects and occurrences, and will "play around" with solutions to challenging problems. These problems require students to think about how the shape of an object affects the properties of that object.

SUGGESTED SCHEDULE/SYLLABUS EMPHASIS

#	Activity Title	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Emphasis
1	Building with Paper									Making Decisions/Questioning B-1.2 Resourcefulness, innovativeness II-C-1.11 Shape
2	Flight Contests									Making Decisions/Questioning B-1.2 Resourcefulness, innovativeness II-C-1.11 Shape
3	Spinning Shapes									Making Decisions/Questioning A-2.13 Original insight, inferences, etc. II-C-1.11 Shape
4	Evapo-racing									Predicting/Questioning B-1.1 Scientific techniques, materials II-C-1.11 Shape
5	Light Paths Through Shapes									Interpreting Data/Manipulating Ideas A-1.32 Accurate information II-C-1.11 Shape

SUGGESTED APPROACH

This mini-unit can be introduced with a discussion of the properties of an ordinary piece of writing paper. When that piece of paper is made into something else, such as a tower, bridge, or paper airplane, do its properties change, and if so, how? At this point, students will raise questions about how properties can change, and these questions can lead naturally into Activities 1, 2, and 3.

The activities in this mini-unit can be conducted in varying sequences and for varying amounts of time, depending on student interest and whether there are related questions and problems students elect to pursue.

MATERIALS

Scrap paper
Newspaper
Paper clips
Toothpicks
Eyedroppers
Water
Timer
Scissors
Floating ghosts or helicopter cutouts
Cylindrical containers (various widths)
Glass containers (various shapes)
Graduated cylinders or beakers
Hand lenses
Magnifying glasses
Large mounted magnifying glass
Discarded eyewear lenses
Camera lenses
Flashlights and penlights
Paper screen
Newsprint paper
Tape, cellophane

MORE IDEAS

1. Visit construction projects to learn more about the structural strengths of various materials as well as different construction techniques.

2. Research the various types of bridges. Have students build model bridges with toothpicks, glue, string, and cardboard. See how many books they will support.

3. Why is the arch a common design in structures?

4. Help students to construct tetrahedrons with mini marshmallows and toothpicks. How does the shape of a tetrahedron affect its strength? What structures can be built using tetrahedrons?

5. Find out how transatlantic cables were made.

6. Research the properties of the materials used in constructing aircraft and spacecraft.

7. Find out what some of the best paper airplane shapes are. Check *The Great International Paper Airplane Book*, by Mander, Dippel, and Gossage, 1967.

8. Visit a maple sugar house to see how maple syrup is made. How does the shape of the evaporating pans affect evaporation?

SYLLABUS EMPHASIS	ACTIVITIES	SUPPLEMENTARY INFORMATION

Problem:

How strong is paper?

Making Decisions/Questioning	
B-1.2	Resourcefulness, innovativeness
II-C-1.11	Shape

1. BUILDING WITH PAPER

Ask students (in groups of 4) to use only one sheet of paper to support a book 8 1/2" above the floor or desk. (It can be done.) Using newspaper, students can try to support the book only at the ends and have it bridge across two desks.

Challenge each group of students to build the tallest structure possible from 10 sheets of paper and 10 paper clips. As another variation, have students build the largest bridge possible from 10 sheets of paper and 10 paper clips.

Conduct a discussion to help students understand how shape affects structural strength. Discuss some of the world's great construction challenges: bridges, tunnels, arches, skyscrapers.

Materials:

Scrap paper
Tape
Paper clips
Newspaper

Problem:

How does shape affect flight?

Making Decisions/Questioning	
B-1.2	Resourcefulness, innovativeness
II-C-1.11	Shape

2. FLIGHT CONTESTS

Use a large area such as the school gym or cafeteria – or an outside area, if there is little or no wind. Have students build airplanes from scrap paper and have contests for different flight categories, such as distance, flight time, and stunt flight. Students can experiment with design and the use of paper clips to seek solutions to the problems posed by the different flight categories.

Discuss the shapes of other objects which move through the air: footballs, baseballs, soccer balls, a javelin, a discus. Discuss how objects would move through an airless medium (vacuum).

Materials:

Scrap paper
Paper clips
Timer

Safety Note:

Provide for protection of eyes during airplane flight. Saffety goggles or using only blunt-nosed airplanes are possible strategies.

Problem:

How does shape affect how paper helicopter cutouts fall?

Making Decisions/Questioning	
A-1.13	Original insight, inferences, etc.
II-C-1.11	Shape

3. SPINNING SHAPES

Have students cut out a floating ghost or a helicopter drawn from the sketch provided. Let students drop the cutout several times. Then ask how they could turn the cutout into a spinning ghost or a helicopter. Allow students to try out their ideas.

Discuss with students the best way to make the cutout spin. How could they make the cutout spin faster? How could they make it fall

Materials:

Floating ghost or helicopter cutouts
Scissors
Paper clips
Paper

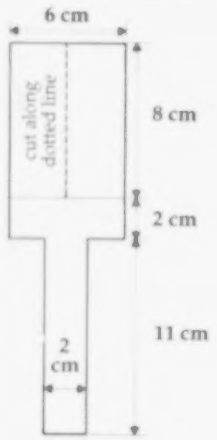
12 cm (width)

20 cm (length)

Floating Ghost

SYLLABUS EMPHASIS Cont'd	ACTIVITIES Cont'd	SUPPLEMENTARY INFORMATION Cont'd

more slowly? Faster? How could they make it spin in the opposite direction? How does the shape (length, width) of the wings affect the spinning? The shape of the tail? Discuss with students how all these changes in shape affect the properties of the helicopters.



Helicopter

Problem:

How fast can water be made to evaporate?

Predicting/Questioning	
B-1.1	Scientific techniques, materials
II-C-1.11	Shape

4. EVAPO-RACING

Drop equal amounts of water onto desk tops. Students should then evaporate the water, using only the toothpick to touch the water directly. Time how long it takes for the water to evaporate, and discuss the most effective and least effective methods.

Over a longer period, set up cylindrical containers of various widths with the same amount of water in each. At the start, ask students to predict how much water will evaporate in each container. After several days, ask students to develop a procedure to compare the amounts of water left in the containers. After completion, discuss how shape and surface area affect evaporation.

Materials:

Toothpicks
Eyedroppers
Water
Cylindrical containers (various widths)
Timer
Graduated cylinders or beakers

Problem:

What path does light follow through water and glass?

Interpreting Data/ Manipulating Ideas	
A-1.32	Accurate information
II-C-1.11	Shape

5. LIGHT PATHS THROUGH SHAPES

Set up water lenses by filling variously shaped clear glass containers with water. Place the containers on newsprint paper, trace their outlines, and leave a space to record information about each container. Darken the room and have groups of 3-4 students use a flashlight to pass beams of light through each container from various directions, and have them draw the direction of the beam on the outline of each container. Discuss how the shape of the container affects the path of light through the water.

Ask students how the shape of a glass lens affects the path of light through the lens. Have students determine if a lens focuses light by trying to focus a light beam on a paper screen with convex and concave lenses.

Discuss why convex lenses focus light and concave lenses do not.

Materials:

Glass containers, various shapes (battery jars, large beakers, soda bottles, vinegar bottles, vegetable oil bottles, steak sauce bottles, etc.)
Newsprint paper
Flashlights and penlights
Paper screen
Hand lenses
Magnifying glasses
Discarded eyewear lenses
Camera lenses

II

ENERGY CHANGES AND ENERGY PATHS

ENERGY CHANGES AND ENERGY PATHS

LEVEL II _____ (GRADE)

PROBLEM OVERVIEW

Children often ask questions about how things work, such as how a refrigerator stays cold, how a lawn mower cuts grass, or how an elevator goes up and down. The observation of simple machines, transportation vehicles, and household appliances can lead to many questions about how these devices work, what kinds and amounts of energy are needed to operate them, and how energy moves and changes as it is applied to these devices.

The problem in this mini-unit is to find out how energy can change in form and how energy is used in everyday machines. As part of the problem solving, children create their own "machines," such as periscopes, and they study more complex "machines," such as bicycles or wheelchairs.

SUGGESTED SCHEDULE/SYLLABUS EMPHASIS

#	Activity Title	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Emphasis
1	Changing Motion Energy to Heat Energy	▨						Measuring/Questioning A-2.12 Ambiguity, contradiction, tentativeness II-D-1 Energy changes, interactions
2	Making Periscopes		▨	▨				Manipulating Materials/Questioning B-1 The practical, technical II-D-2 Energy transfer, system
3	Paper Clip Pickup				▨			Measuring/Communicating Information A-2.14 Careful, systematic investigation II-C-2.3 Energy, amounts available
4	Magnetism Moves Through Some Materials					▨		Observing/Recording Data A-1.32 Accurate information II-C-2.2 Energy movement, between, through
5	Shifting Gears						▨	Interpreting Data/Questioning B-1.3 Technique efficiency, simplicity, etc. II-C-2.2 Energy movement, between, through

SUGGESTED APPROACH

Since energy is an abstract concept and cannot be seen or otherwise observed directly, students will need many experiences with situations and devices in which energy is used, changed, and moved. The activities in this mini-unit will make a start toward providing these experiences and can be used in any order desired.

Begin the mini-unit by asking students to share their own knowledge of and experiences with energy. Raise such questions as: "What does energy mean to me? How do I know when objects have it? What does it look like, feel like, sound like? How can I measure it? How does it change, move, get used?" As students work through activities in this mini-unit, they will be able to refine and state more precisely their concept of energy.

Give students ample opportunities to ask and answer their own questions as they work through these activities. Give them time, also, to work on other questions that interest them in an activity or to bring in other everyday machines and investigate how they use energy.

Use these activities as an opportunity to introduce students to technology and to develop positive attitudes toward technology. Help all students to enjoy working with and investigating simple devices and machines, to value resourcefulness and innovativeness, to care about the efficiency and simplicity of technical devices and techniques, and to recognize the benefits and burdens that technology brings, even in using such a seemingly simple machine as a bicycle or wheelchair.

MATERIALS

Small baby food jars with lids
Thermometers
Newspaper or sheets of "bubble" packing collected from shipping boxes
Masking tape
Mirrors or mirror tiles
Milk cartons (varying sizes)
Cardboard tubes
Oatmeal boxes
Scrap cardboard
Potato chip cans
Scissors
Light source, such as a strong flashlight
Bar magnets (steel, chrome, alnico)
Paper clips
Paper
Sponges (thinly cut)
Various kinds of metals in thin strips, including iron and steel
Plastic, thin strips
Wood, thin strips
Bicycle (3-, 5-, and/or 10-speed)
Bicycle stand
Wheelchair

MORE IDEAS

1. Visit an appliance repair service to observe the workings of refrigerators, ranges, and televisions.

2. Make arrangements to have a representative of the telephone company visit the class to explain how a telephone works. Include a discussion of how an amplification device for the hearing impaired works.

3. Use discarded telephones to learn about the energy transformations in telephone systems.

4. Visit a local electrical energy generating facility and discuss how electrical power gets to our homes.

5. Research how magnets are made and how they are used in industry.

6. Ask how our lives would be different without magnets. Conduct a magnet scavenger hunt at school and at home (students can investigate with their parents) to see how many devices contain magnets. Develop a class master list from the results.

7. Research how various kinds of bicycles differ from one another. What differences are there among racing bicycles, touring bicycles, and mountain bicycles? Invite a bicycle shop owner to talk to the class about the different kinds of bicycles. Compare the various types of wheelchairs (racing, general use).

SYLLABUS EMPHASIS	ACTIVITIES	SUPPLEMENTARY INFORMATION

Problem:

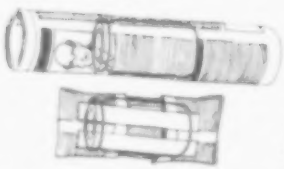
What heats the water?

Measuring Questioning	
A-2.12	Ambiguity, contradiction, tentativeness
II-D-1	Energy changes, interactions

1. CHANGING MOTION ENERGY TO HEAT ENERGY

In pairs, have students add equal amounts of water to two baby food jars, record the temperatures, and cap tightly. Ask if students can find a way to heat the water without actually applying heat to it. One method is to wrap each jar in newspaper or "bubble" packing and tape (as illustrated). Team members leave one jar on the desk and shake the other jar (taking turns) for at least *four* minutes. Then they record the water temperature in each jar.

Discuss the energy change and transfer (from the mechanical energy of moving muscles to increased heat energy in the water). Compare to the freezing process – the removal of heat energy. Discuss the importance of insulation in this activity.



Baby food jar wrapped in newspaper

Newspaper folded over and taped

Materials:

Small baby food jars with lids
Thermometers
Newspaper or "bubble" packing sheets
Masking tape

Problem:

Can light change direction?

Manipulating Materials Questioning	
B-1	The practical, technical
II-D-2	Energy transfer, system

2. MAKING PERISCOPES

Discuss with students how light could be made to change direction. How would this help us see things we couldn't ordinarily see? Ask students if they know of any devices which help us see around corners, etc. If students mention periscopes, ask if they know how they are constructed, and if they can figure out how to make one.

Students construct periscopes by using tubes or columns made from milk cartons, cardboard tubes or chip cans, and small mirror tiles or small mirrors. The mirrors can be angled with tape and scrap cardboard on the interior of the tubes.

Students can then compete in a "periscope shoot" by building periscopes with two or more mirrors that will focus light onto a dot on a wall or ceiling.

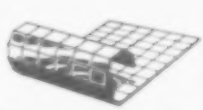
Discuss how light moves and how a periscope makes use of this phenomenon.

Materials:

Small mirrors or mirror tiles
Milk cartons – varying sizes
Cardboard tubes
Oatmeal boxes
Potato chip cans
Masking tape
Scrap cardboard
Scissors
Light source, such as a strong flashlight

Safety Note:

If the mirrors or mirror tiles have sharp edges, these edges should be covered with masking tape before students use the mirrors or tiles.



Sheet of Mirror Tile

Potato Chip Can

Viewing opening

Paper Tube

Tubes Taped Together

SYLLABUS EMPHASIS Cont'd	ACTIVITIES Cont'd	SUPPLEMENTARY INFORMATION Cont'd

Problem:

Which magnet is strongest?

Measuring/Communicating Information	
A-2.14	Careful, systematic investigation
II-C-2.3	Energy, amounts available

3. PAPER CLIP PICKUP

Give students data sheets with a column for each different bar magnet. How many paper clips will each magnet pick up? Which magnet is strongest?

Can magnets be put together to pick up even more paper clips? How? What makes the strongest magnet?

Materials:

Bar magnets (chrome, steel, alnico)
Paper clips

Problem:

What materials can magnetism pass through?

Observing/Recording Data	
A-1.32	Accurate information
II-C-2.2	Energy movement, between, through

4. MAGNETISM MOVES THROUGH SOME MATERIALS

Discuss with students whether they think magnetism can move through materials. Why or why not? If they think it can, ask them to predict which kinds of materials it might move through. Have students develop a plan to carry out the test. Students should assemble different kinds of materials and then test them, starting with paper. Have students keep a data table indicating which materials magnetism will move through and which it won't move through.

Can the kinds of materials that magnetism will and won't pass through be classified? What are some of the classifications?

Materials:

Bar magnets
Paper
Sponges (thinly cut)
Various kinds of metals in thin strips, including iron and steel
Plastic, thin strips
Wood, thin strips

Problem:

What makes a bicycle go?

Interpreting Data/ Questioning	
B-1.3	Technique efficiency, simplicity, etc.
II-C-2.2	Energy movement, between, through

5. SHIFTING GEARS

Place a bicycle in a bicycle stand. By moving the pedals, shifting the gears, and applying the brakes, students can trace the transfer of energy through the bicycle system. Also trace the transfer of energy through a wheelchair. Questions to address include:

How does energy move through the bicycle or wheelchair?

Where is force applied to the bicycle or wheelchair to make it go? To stop it?

In which direction does each bicycle gear move?

In which gear is it easiest to move the bicycle pedals? Hardest?

In what situation would you use each gear?

Materials:

3-, 5-, and/or 10-speed bicycle
Bicycle stand
Wheelchair

Bicycle Gears and Chain

II

DANDELIONS:
"WEED OR WONDER?"

DANDELIONS: "WEED OR WONDER"?

LEVEL II _____ (GRADE)

PROBLEM OVERVIEW

What child hasn't delighted in blowing dandelion seeds from the seed heads on a warm summer day? Simply because the dandelion is such a common plant, it is natural for children to study it in school. Curious children already will have many questions about dandelions. The answers to these questions may be surprising to children and adults alike because the dandelion, as a highly successful plant species, has many unique survival characteristics.

SUGGESTED SCHEDULE/SYLLABUS EMPHASIS

#	Activity Title	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Emphasis
1	Attitudes Toward Dandelions									Interpreting Data/Communicating Information A-2.11 Uncertainty of information, verification II-A-1 Flowers, sufficient seeds, survival, new generation
2	Dandelions Everywhere									Observing/Recording Data A-1.1 Appreciating natural world II-A-1.5 Plant potential for offspring
3	Growing Dandelions									Making Decisions/Communicating Information A-2.14 Careful, systematic investigation II-A-1.33 Germination, suitable conditions
4	Dandelion Flowers									Observing/Questioning A-1.11 Complexity, diversity, intricacy, etc. II-A-1.2 Flowers, seeds
5	Dandelion Seeds									Observing/Questioning A-1.11 Complexity, diversity, intricacy, etc. II-A-1.3 Seed characteristics, survival
6	Dandelion Populations									Measuring/Recording Data A-2.14 Careful, systematic investigation II-A-1.52 Actual conditions, survival, population
7	Dandelion Vegetables									Manipulating Materials/Acquiring Information A-1.12 Resource, human needs II-B-1 Plants, animal food supply, sun energy
8	Dead Dandelions									Making Decisions/Acquiring Information A-2.26 Beliefs and values of others II-B Different kinds, plants, animals, dependency, community

SUGGESTED APPROACH

The best time to conduct this mini-unit is in spring, when the dandelions are in their first full bloom. To prepare for the activities, dandelion seeds can be ordered from one of several seed companies and planted successively over time. This will ensure that chemically untreated dandelions in several stages of their life cycle are available to prepare dandelion vegetables.

Draw on students' experiences with dandelions to raise questions that can be used to investigate the dandelion's life cycle and to explore people's attitudes toward dandelions.

Conduct as many of the activities as possible outdoors, but take special care to make sure that students are not handling dandelions that have been treated with herbicides.

MATERIALS

Wild dandelions
Dandelion seed
Chart paper
Planter boxes or a garden area
Potting soil
Hand lenses
Giant mounted lens
Garden trowel
Centimeter rulers
Meter sticks
String
Stakes
Stalking the Wild Asparagus, by Euell Gibbons, 1962.

MORE IDEAS

1. Help students to find out where the name "dandelion" came from.

2. Locate dandelions growing in an unmowed field and in a mowed lawn. Observe and record the differences in the growth patterns of the dandelions in the two areas.

3. Make dandelion chains and other creative products.

4. Research the common methods of destroying dandelions. Ask a representative from Cooperative Extension to talk to students about dandelions and the methods people use to destroy them.

5. Research other flowers that are similar to dandelions. How do people feel about these other flowers as compared to the dandelion?

6. Find out whether dandelions are native to North America. How might they have gotten here and when?

7. Find out whether dandelions are grown commercially. What are they grown for?

8. Research the past medicinal uses of dandelions.

9. With the aid of the librarian, help students to research songs, poetry, art, and folklore about dandelions. Does the dandelion occur in children's play folklore or in rhymes? Have interested students write dandelion songs, poetry, or folklore.

10. Find out whether a dandelion lives through the winter. Do its leaves live through the winter?

11. Observe dandelions over time or do library research to determine what animals, besides humans, eat dandelions.

12. Dandelion leaves turn bitter as the dandelion flowers begin to develop. Discuss what advantage this gives to the dandelion plant.

13. Observe the outdoors through late autumn to determine the last plant to produce flowers before winter. Record the date of this event on a natural events calendar. (See the unit, "Plant Life Cycles.")

14. Dig dandelion roots from old fields for spring forcing. Refer to *Stalking the Wild Asparagus*, by Euell Gibbons, 1962.

SYLLABUS EMPHASIS	ACTIVITIES	SUPPLEMENTARY INFORMATION

Problem:

Who likes dandelions?

Interpreting Data/ Communicating Information	
A-2.11	Uncertainty of information, verification
II-A-1	Flowers, sufficient seeds, survival, new generation

1. ATTITUDES TOWARD DANDELIONS

Take students outdoors to observe dandelions growing. Discuss with the class what they know about dandelions, including their life cycle. Ask students to share their feelings and attitudes about dandelions.

Help the class to develop a survey that would sample the attitudes of adults toward dandelions. Be sure they include older adults in their sample. Help students to draw and analyze a histogram of their results. How do most people feel about dandelions? How do attitudes about dandelions vary with age?

Materials:

Dandelions growing outdoors

Safety Note:

Students should not handle dandelions if they are growing in areas which have been treated with herbicides.

Problem:

Do dandelions grow everywhere?

Observing/Recording Data	
A-1.1	Appreciating natural world
II-A-1.5	Plant potential for offspring

2. DANDELIONS EVERYWHERE

Take students outdoors and begin to catalog the locations where dandelions grow. Ask students to continue this task in their before-and-after school activities for the next few days. Develop a list of locations where dandelions grow. Can students infer any places where they don't grow? Can students produce any explanations for why dandelions seem to grow everywhere?

Materials:

Chart paper

Problem:

Can dandelions be grown by people?

Making Decisions/Communicating Information	
A-2.14	Careful, systematic investigation
II-A-1.33	Germination, suitable conditions

3. GROWING DANDELIONS

As an aid to studying dandelions more closely, grow them in deep planter boxes indoors or in an outdoor garden. Ask students if they think dandelions can be grown by people, as other flowering plants are. Help students to develop a plan to find out if dandelions can indeed be grown this way.

Discuss with the class how they'll obtain the dandelion seeds they'll grow themselves. Options include collecting dandelion seeds from wild seed heads or ordering seeds from a seed catalog.

Materials:

Dandelion seeds
Planter boxes or a garden area
Potting soil

Safety Note:

Seeds should not be collected from plants in areas which have been treated with chemical herbicides.

SYLLABUS EMPHASIS Cont'd	ACTIVITIES Cont'd	SUPPLEMENTARY INFORMATION Cont'd
Problem: How can dandelions survive in a mowed lawn? Observing/Questioning A-1.11 Complexity, diversity, intricacy, etc. II-A-1.2 Flowers, seeds	**4. DANDELION FLOWERS** Observe both the planted dandelions and wild dandelions over time. Dig up a few dandelions to observe their roots. What characteristics allow the dandelion plant to survive in a mowed lawn (no stem, leaves that hug the ground and shade out plants germinating under them, deep taproot that can fuel regrowth, low-growing flowers). Students will generate many questions about the flowers. Some of these include the following: How many flowers does a single dandelion produce? How many times in a season does a single plant flower? How many petals does a dandelion have? Is the number of petals the same in different flowers? How long does a dandelion's flower last? What is the flower stalk like? Does this kind of stalk benefit the plant in any way? What happens to the green bracts surrounding the flower at night? What happens to the bracts after the flower goes to seed? What pollinates a wild dandelion?	**Materials:** Dandelions Hand lenses Giant mounted lens Garden trowel
Problem: Why are dandelions so widespread? Observing/Questioning A-1.11 Complexity, diversity, intricacy, etc. II-A-1.3 Seed characteristics, survival	**5. DANDELION SEEDS** Have students observe and measure what happens as the flower goes to seed. What happens to the stalk? (The stalk elongates and the seed head is lifted into the wind for seed dispersal.) How much does it grow? How long does this take? How does this match with the typical time between lawn mowings? What happens to the bracts during the time the stalk is growing? Where do the seeds form? How many seeds are formed? Is this the same for all seed heads? How far can students blow the seeds in a seed head? How do the seeds disperse? Discuss with students how the answers to these questions explain why dandelions are so widespread.	**Materials:** Dandelions Hand lenses Giant mounted lens Centimeter rulers
Problem: What is the size of the school's dandelion population? Measuring/Recording Data A-2.14 Careful, systematic investigation II-A-1.52 Actual conditions, survival, population	**6. DANDELION POPULATIONS** Review with students the large number and widespread occurrence of dandelions. Discuss with students how many dandelions they think grow around the school. Develop with students a sampling technique to estimate the size of the school's dandelion population. Set up sampling grids about 1 meter square, at various locations around the school. From the samples estimate the dandelion population. How many seeds would this population produce? If they all germinated around the school, what would be the dandelion population in the next generation? Why doesn't this happen?	**Materials:** Meter sticks String Stakes

SYLLABUS EMPHASIS Cont'd	ACTIVITIES Cont'd	SUPPLEMENTARY INFORMATION Cont'd
Problem: What are dandelions good for? Manipulating Materials/ Acquiring Information A-1.12 Resource, human needs II-B-1 Plants, animal food supply, sun energy	**7. DANDELION VEGETABLES** Discuss with students how animals use dandelions and how dandelions fit into the "web of life." Discuss with students whether dandelions have any other human uses. Have them carry out library research and question adults (especially grandparents) about dandelion uses. Some students with handicapping conditions may need access to research materials of varying reading levels to complete this assignment. To what extent was the dandelion a food source in the past? Was the dandelion used as a medicine? How many parts of a dandelion may be served as a vegetable? (Four) Use only the dandelions that have been grown in the classroom or outdoor garden to prepare dandelion vegetables (boiled or raw greens, crown salad or boiled crowns, cooked developing blossoms, sliced young dandelion root). Prepare dandelion "coffee" from dandelion root. Discuss how dandelion wine is made.	**Materials:** Dandelion plants (all parts) *Stalking the Wild Asparagus*, by Euell Gibbons, 1962 *The Reasons for a Flower*, by Ruth Heller *Plants That Never Bloom*, by Ruth Heller *Exploring Fields and Lots*, by Seymour Simon **Safety Note:** Do not use dandelions which have been chemically treated.
Problem: What's wrong with dandelions? Making Decisions/ Acquiring Information A-2.26 Beliefs and values of others II-B Different kinds, plants, animals, dependency, community	**8. DEAD DANDELIONS** Review with students the results of the survey they took about dandelions. Have students interview the same people again to find out why they do or do not like dandelions and to see if they make it a practice to kill dandelions. Make a histogram of the results. What are the main reasons people like dandelions? What are the main reasons people don't like dandelions? How many people kill dandelions? How do they kill them? Ask each student to decide individually whether dandelions should be killed. Each student should write a paragraph about the decision, giving supporting reasons. Discuss the paragraphs together.	**Materials:** Survey from first activity Chart paper

II

PLANTS AND ANIMALS:
"HOW DO THEY DEPEND ON EACH OTHER?"

PLANTS AND ANIMALS: "HOW DO THEY DEPEND ON EACH OTHER?" LEVEL II _____ (GRADE)

PROBLEM OVERVIEW

Children often observe animals feeding. Most commonly, these observations result from at-home experiences with pets or farm animals. Most youngsters have seen animals feeding on plants or on other animals, either through actual experience or from movies or television. Some students may observe that squirrels, for example, do not always eat the same type of plant and that field mice are a food source for more than one type of animal. Such feeding patterns cause simple food chains to branch into food webs. The bigger problem for students is to see how plants and animals are part of a still larger group – a community.

SUGGESTED SCHEDULE/SYLLABUS EMPHASIS

#	Activity Title	Day 1&2	Day 3&4	Day 5&6	Day 7&8	Day 9&10	Day 11&12	Day 13&14	Day 15&16	Emphasis
1	Animal Food									Generalizing/Manipulating Ideas A-1.32 Accurate information II-B-1.1 Food chain
2	Owl Dinners									Inferring/Questioning A-1.21 Individual life, precious II-B-1.1 Food chain
3	Human Food Chains									Creating Models/Acquiring Information A-1.12 Resource, human needs II-B-1.1 Food chain
4	Insects									Observing/Questioning A-1.11 Complexity, diversity, intricacy, etc. II-B-1 Plants, animal food supply, sun energy
5	Food Chains in Water									Inferring/Acquiring Information A-1.32 Accurate information II-B-1.1 Food chain
6	Illustrating a Food Web									Creating Models/Communicating Information A-1.11 Complexity, diversity, intricacy, etc. II-B-1.2 Food web
7	Natural Communities									Observing/Questioning A-1.21 Individual life, precious II-B Different kinds, plants, animals, dependency, community

SUGGESTED APPROACH

Outdoor sites can be used for activities which will lead to greater understanding about the interdependencies of plants and animals and the nature of both food chains and food webs. Students will ask many questions, such as: What animals eat only plants? What animals eat only animals? What animals feed on both plants and animals?

Students can be exposed to different varieties of plants and animals through mini-field trips on the school grounds. The activities can vary in length from one-half to an entire class period or more. Observations of an area over longer periods of time may answer questions as to how plants get food, what food chains exist on land and water, and how populations form communities. These activities can be ongoing throughout the year as children observe seasonal changes in the interdependence of plants and animals.

MATERIALS

Live classroom animals
Pets
Print and nonprint materials relating to food chains
Owl pellets
Dissecting probes
Poster board
Paste
Print and nonprint materials on small mammals
Oaktag
Scissors
Crayons or colored pencils
Print and nonprint materials on food sources
Muslin or mosquito netting
Coat hangers
Large dowels, 1 1/2 or 2 inches by 3 feet
Stapler
Stakes
String
Large and small jars with perforated lids
Small covered plastic aquaria
Dip nets
Giant mounted lens
Hand lenses
Collecting jars or plastic cups
Print and nonprint materials on pond life
Yarn
Photographs or drawings of plants and animals
Aquaria
Various plants and animals for aquaria
Print and nonprint resource materials, such as *The Curious Naturalist*, by John Mitchell, 1980
Collecting tools

MORE IDEAS

1. Visit an aquarium supply store to learn how different kinds of aquatic animals depend on one another and on plants.

2. Visit a natural history museum, zoo, or farm to learn more about animal feeding, food chains, and food webs.

3. Brainstorm: What would happen to food chains and food webs if all animals had the same food-gathering structures?

4. Explore patterns of human eating around the world. Create posters or a classroom wall mural depicting 1) human groups mainly dependent on grains and fish and 2) those who depend more on cattle and hogs. Are there other patterns? A variation would be to compare the human eating patterns of today with those of previous cultures in history.

5. Where do human foods grow? How are they harvested? Transported? Packaged? Marketed?

6. Investigate animal adaptations that allow the animals to specialize in eating certain kinds of foods. Using "throw-away" or "found" materials and a variety of foods (seeds, nuts, leaves, eggs, etc.) students can construct devices that show how some animals 1) bite and grind leaves; 2) dig up roots; 3) break nuts and seeds; 4) trap worms, flying insects, and underground animals; or 5) gather eggs.

7. Find an area where there are rocks and rotting logs and observe animal escape behavior. Animals are usually "escapers" or "freezers" when logs and rocks are overturned. How does escape behavior affect food chains? What features are common to "escapers"? To "freezers"? How do the animal types compare?

SYLLABUS EMPHASIS	ACTIVITIES	SUPPLEMENTARY INFORMATION
Problem: What do animals eat? Generalizing/Manipulating Ideas A-1.32 Accurate information II-B-1.1 Food chain	**1. ANIMAL FOOD** Provide students with access to one or more classroom animals so that they can observe the eating habits of the animals. (If students have already performed this activity in Level I, repeating the activity will provide review and reinforcement.) Ask students to determine what these animals eat, and what pets at home eat. For home pets, students might wish to check the nutrition information on cans and bags of pet food. Have students select one animal and list what it eats. Then have them illustrate this in a simple diagram, with lines drawn to the animal from what it eats. Display all diagrams and discuss them with students. What summary statements can they make about all the diagrams taken together? Ask each student to select a diagram which includes an animal as part of what the classroom animal or pet eats. Use resource materials to determine what that first animal eats. Have students draw a diagram showing this level of eating relationship. Introduce the concept of food chain and ask students to draw or make collages of other food chains.	**Materials:** Live classroom animals Pets Print and nonprint materials relating to food chains Materials should reflect a wide range of reading abilities. This may be particularly appropriate for some students with handicapping conditions. (Ex. *Pets in a Jar: Collecting and Caring for Small Animals*, by Seymour Simon)
Problem: What does an owl eat for dinner? Inferring/Questioning A-1.21 Individual life, precious II-B-1.1 Food chain	**2. OWL DINNERS** Provide teams of 2-3 students with owl pellets and allow them to carefully pull the pellets apart. As they proceed, ask leading questions. What are they examining? What are they finding in their examination? How many bones are there in the pellet? Are they from the same or different animals? Can they reconstruct any skeletons? Have students paste the skeletons on poster board. From what animals do the skeletons come? If students haven't already guessed, explain that they have dissected owl pellets, and ask them to draw a food chain from their observations. Now ask them to use resource materials to determine what the small mammals whose skeletons they examined ate. Display the completed food chains.	**Materials:** Owl pellets, collected from barns or from beneath woodland trees, or purchased from scientific supply houses Dissecting probes Poster board Paste Print and nonprint materials at a variety of ability levels on small mammals

SYLLABUS EMPHASIS Cont'd	ACTIVITIES Cont'd	SUPPLEMENTARY INFORMATION Cont'd

Problem:

What do I eat?

Creating Models/ Acquiring Information	
A-1.12	Resource, human needs
II-B-1.1	Food chain

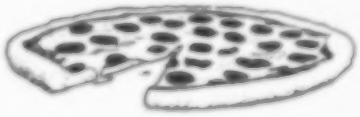
3. HUMAN FOOD CHAINS

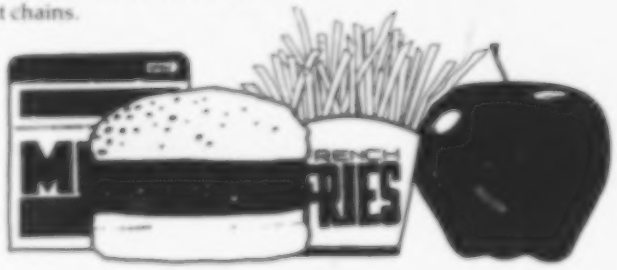
As a take-home assignment, ask each student to list the foods eaten for dinner that night. Working in small groups, have students use resource materials to trace each food eaten back to a plant. Students can then construct mobiles which illustrate the various food chains from which the dinner came. Each student, of course, is at the top of the mobile.

Discussion can focus on the number of food chains that contribute to a dinner, the ultimate source of each food chain, and the numbers of links in the different chains.

Materials:

Poster board or oaktag
Scissors
Crayons or colored pencils
Print and nonprint materials (at a variety of ability levels) on food sources





Problem:

Where do insects get their food?

Observing/Questioning	
A-1.11	Complexity, diversity, intricacy, etc.
II-B-1	Plants, animal food supply, sun energy

4. INSECTS IN THE GRASS

Ask students where insects obtain their food. Ask them how they could determine whether their answer is correct, and help them to develop a plan to find out. A typical plan might have teams of 3 or 4 students mark off two grids, 1 or 2 meters square in size. One grid can be swept thoroughly with an insect net and the insects classified. Then students can quietly observe the second grid for evidence of what each kind of insect eats. In most cases, the students will find that the insects eat plants. Students can classify the plants growing in the test grid and link each kind of plant to the insects which eat it. Release all insects when the study is finished.

Discussion questions can include: What kinds of insect and plant populations were discovered? Where do plants get their food? Each student can draw food chains to culminate the activity.

Materials:

To construct insect nets:

Muslin or mosquito netting
Coat hangers
Large dowels, 1 1/2 or 2 inches by 3 feet
Stapler

To mark off grids:

Stakes
String

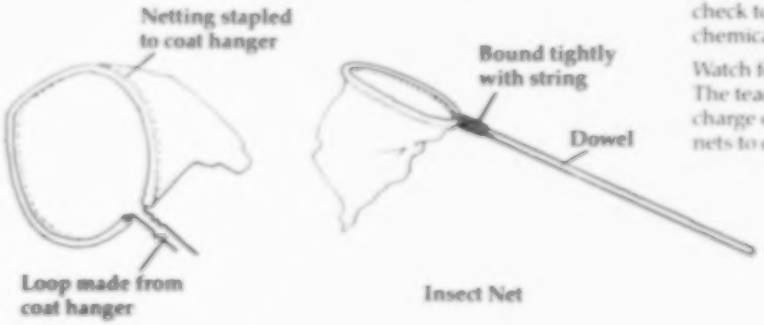
To collect insects:

Assortment of large and small jars, with perforated lids
Small covered plastic aquaria

Safety Notes:

Make sure no poison ivy occurs in the search area. While a mowed lawn may be the best location for this activity, check to make sure that it has not been chemically treated.

Watch for stinging insects in the nets. The teacher should probably take charge of removing insects from the nets to collecting jars.



Insect Net

SYLLABUS EMPHASIS Cont'd	ACTIVITIES Cont'd	SUPPLEMENTARY INFORMATION Cont'd
Problem: What food chains are found in water? Inferring/Acquiring Information A-1.32 Accurate information II-B-1.1 Food chain	**5. FOOD CHAINS IN WATER** Explore an aquatic site to find simple food chains. Use dip nets to obtain samples of bottom sediment as well as to capture small plants and animals. Put these into collecting jars. Which animals might eat plants? Other animals? Students should also look for signs of larger animals in and around the aquatic site. Discuss the role of plants as well as the kinds of plants in the aquatic food chain. Have students discuss ways in which aquatic and terrestrial food chains differ. When finished with the activity, release the specimens collected at the same site.	**Materials:** Dip nets Hand lenses Giant mounted lens Collecting jars or plastic cups Print and nonprint materials (at a variety of ability levels) on pond life
Problem: Who eats what or whom? Creating Models/ Communicating Information A-1.11 Complexity, diversity, intricacy, etc. II-B-1.2 Food web	**6. ILLUSTRATING A FOOD WEB** Ask each student to select a plant or animal to portray in a food chain. Students can bring in photographs or make drawings of their selection or even dress up as their selection. Take the class outdoors, if possible, to complete the activity. Then, ask students, one at a time, to complete one of the following sentences: "I eat. . . ." or "I am eaten by. . . ." The sentence should be completed with a plant or animal portrayed by one of the other students. Connect brightly colored yarn between these students. Continue until students can no longer complete the sentences or until the food web has become very complex. Discuss with the students the food web model they have created. What do they think about it? How do they feel about it? Later, ask each student to write about one food chain in the food web.	**Materials:** Yarn Photographs or drawings of plants and animals

SYLLABUS EMPHASIS Cont'd	ACTIVITIES Cont'd	SUPPLEMENTARY INFORMATION Cont'd

Problem:

Where are communities of plants and animals found?

Observing/Questioning	
A-1.21	Individual life, precious
II-B	Different kinds, plants, animals, dependency, community

7. NATURAL COMMUNITIES

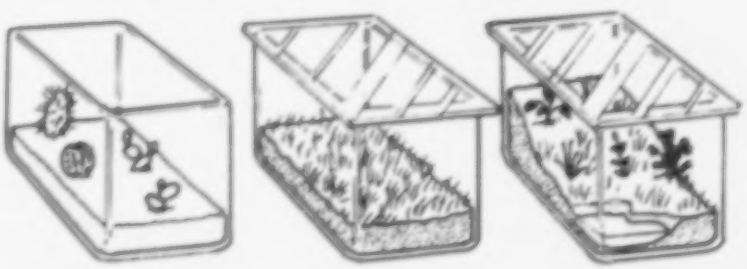
Discuss with students what a human community is. What are its characteristics? List them on the board. Could students find "communities" of plants and animals in the natural world which are like human communities? Where might they be found? List ideas on the board, such as, in ponds, under rocks, on and under rotting logs, in an old field, at a woodland edge, or on the school grounds. Examples of communities include the animals that feed at the bird feeder, the animals and plants in a terrarium or aquarium, or an ant farm.

Help students to plan an investigation of one or more of these communities. Make sure the plan includes a way to return the community to its natural state when the students are finished. When the investigations are completed, have students list the plants and animals in each community and describe how they depend on each other. What are some food chains in each community? Food webs? What is the source of the food supply?

As a culminating activity, help students to replicate in the classroom simplified natural communities such as those found in woodlands, deserts, grasslands, bogs; fish aquaria; frog aquaria; ant farms; window bird feeding stations. What are the needs of the animals in each community? What are the needs of the plants? How do they depend on each other?

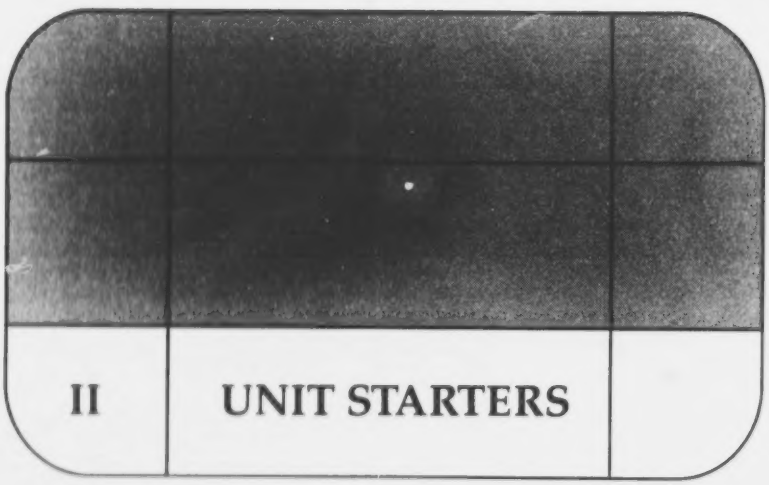
Materials:

Aquaria
Various animals and plants to illustrate different natural communities
Print and nonprint resource materials (at varying ability levels) such as *The Curious Naturalist*, by John Mitchell, 1980
Hand lenses
Giant mounted lens
Collecting tools



Desert Grassland Woodland

Natural Communities



II UNIT STARTERS

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UNIT STARTERS

LEVEL II

Grade Level	Syllabus Connection	Focus Question	Problem Overview
☐	Observing/Questioning A-2.12 II-C-2.2/II-D-2	Is that really you in the mirror?	Students may believe a mirror reflects their true appearance. Have students compare their mirror images to photographs of themselves. This comparison can lead to many questions about how light moves and how it is reflected.
☐	Predicting/Classifying A-1.11 II-C-2.1	What things do magnets attract?	Many students have played with magnets. Asking them to predict which objects can and cannot be attracted to a magnet focuses the problem. Students can then test their predictions and identify the properties common to magnetic material.
☐	Recording Data/ Communicating Information B-2.2 II-D-1	What works in your kitchen?	Students are probably aware of the many appliances involved in food preparation and clean up. Home surveys and class brainstorming can focus attention on these appliances and may lead to further investigation of how they work and what types of energy they provide.
☐	Generalizing/Questioning A-2.12 II-C-2.2/II-D-2	Are fingers good thermometers?	Students usually assume that objects that feel cold have lower temperatures than objects that feel warmer. Have students feel several different surfaces (metal, wood, cloth, and paper) in the classroom and rank them from coldest to warmest. Use a thermometer to measure the temperatures of these surfaces; note discrepancies. Focus student discussion on the flow of heat from their fingers through the objects involved.
☐	Generalizing/Classifying A-1.33 II-C-2.2/II-D-1	How do objects make sound?	Students have learned to take the sounds they hear for granted. But what causes sounds to be produced? Ask students to play a song using their rulers and then to design some simple musical instruments. To focus the problem, investigate what these sound makers have in common.
☐	Manipulating Materials/ Questioning A-2.13 II-D-1/II-D-2	Where does the energy go?	Rube Goldberg, a cartoonist, was famous for his sketches of complicated contraptions that performed simple jobs. Students can build a "Rube Goldberg" device that actually works, and use it to investigate energy transfers in a system. The challenge is to include the largest number of energy transformations and forms of energy and to have energy travel through space the greatest number of times. For example, devise an automatic balloon popper or a better mousetrap.

UNIT STARTERS

LEVEL II

Grade Level	Syllabus Connection	Focus Question	Problem Overview
	Observing/Questioning A-1.11 II-C-2.2/II-D-2	What can you see in a raindrop?	Students can observe the shape, color, and brightness of raindrops and see images in them. Many new problems will arise: Where does the image come from; why is it upside down; how can a new image be placed in the raindrop; where can other natural water lenses be found? Additionally, students can track raindrops down the pane, analyze the "river systems" formed, and add substances to the outside of the pane to see how the raindrop patterns change.
	Predicting/Questioning A-1.32 II-D-2	Where does an echo come from?	Students can create their own echoes by standing well away (more than 500 ft.) from the side of a building and clapping two blocks of wood together. This activity can lead to many questions about the reflection of sound: what surfaces reflect or don't reflect sound; how far away from an object must a person be to create an echo; how can one create reverberation or magnify sound? Some students may even work on measuring the speed of sound.
	Making Decisions/ Communicating Information A-1.2 II-A-2.2	What is the best thing to do if you find a baby bird?	It is natural for children who find a baby bird – or other animal – to decide that it is an orphan and to bring it home for nurturing. By placing a bird house near the classroom window, or by finding a nearby nest, students can observe the kinds of care parent birds provide their young. Students will then be more knowledgeable about what to do with any baby bird.
	Observing/Questioning A-2.11 II-A-2.41/II-B-2	Can you catch more flies with honey than with vinegar?	Students may have heard the expression "you can catch more flies with honey than with vinegar," a suggestion that more can be accomplished when people are polite and pleasant to one another. Investigating the validity of the saying may lead students to learn about animal populations and how they are dependent on a particular food supply.
	Generalizing/Communicating Information A-2.12 II-A-2.3	Does a fish have to learn how to swim?	Many young animals are cared for and taught by their parents, but fish never see their parents. Identification of the kinds of care parents do provide can lead to questions about how animals survive without parental care, and whether some behaviors are instinctive or are learned.

UNIT STARTERS

LEVEL II

Grade Level	Syllabus Connection	Focus Question	Problem Overview
	Observing/Recording Data A-2.11 II-A-2.1	Do woolly bear caterpillars predict the weather?	An adage says that the wider the black bands on a woolly bear, the more severe the coming winter will be. By collecting and observing woolly bears throughout their life cycles, students will have the necessary data to solve this problem.
	Generalizing/Classifying A-1.12 II-A-1.4	What do early spring flowers have in common?	Early spring flowers – crocuses, daffodils, narcissus, hyacinths, tulips – most commonly develop from bulbs. If the teacher plants in the fall a varied spring bulb garden, or forces bulbs indoors, students can examine (and dig up) the spring plants to see what they have in common. Further investigation can determine why bulbs seem to produce the first flowers of spring.
	Creating Models/ Acquiring Information A-2.12 II-B	Who is a part of your community?	By identifying the factors that define the local human community, students can extend their concept of human community to an understanding of a natural community. The members of the natural community that exists within 25 feet of and on all sides – north, south, east, west – of the school building can then be identified. Finally, students can create models to indicate how the members of this natural community are dependent on one another.
	Inferring/Questioning A-1.33 II-A-2.3/II-B-1	What's in a gall?	Students may have noticed the bumps growing on goldenrod stems and on other plant tissues. These bumps, known as galls, can be collected and examined. This activity is likely to generate many more questions about galls and the insects that live in them, including questions about plant and animal dependencies and the degree to which insect parents provide care for the young they deposit in galls.
	Inferring/Recording Data A-1.33 II-B-2	Where do robins find earthworms to eat?	Students may have noticed that more robins seek and find earthworms in one area than another. Determining the relative sizes of the earthworm populations in these areas and how they affect the robin population focuses the problem.

APPENDICES

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APPENDIX A

Students with Handicapping Conditions

The Board of Regents, through revising Part 100 Regulations of the Commissioner and the Action Plan, has made a strong commitment to integrating the education of students with handicapping conditions into the total school program. According to Section 100.2(s) "Each student with a handicapping condition, as such term is defined in Section 200.1(ii) of this Chapter, shall have access to the full range of programs and services set forth in this Part to the extent that such programs and services are appropriate to such student's special educational needs." Districts must have policies and procedures in place to make sure that students with handicapping conditions have equal opportunities to access diploma credits, courses, and requirements.

The majority of students with disabilities have the intellectual potential to master the curricula content requirements for a high school diploma. Most students who require special education attend regular education classes in conjunction with specialized instruction and/or related services. These students must attain the same academic standards as their nonhandicapped peers in order to meet these requirements. For this reason, it is very important that at all grade levels students with handicapping conditions receive instruction in the same content areas so as to receive the same informational base that will be required for proficiency on statewide testing programs and diploma requirements.

The teacher providing instruction through this syllabus/ curriculum has the opportunity to provide an educational setting which will enable the students to explore their abilities and interests. Instruction could be provided to students with handicapping conditions either by teachers certified in this subject area or by special education teachers. Teachers certified in this subject area would be providing instruction to students who are recommended by the Committee on Special Education (CSE) as being able to benefit from instruction in a regular educational setting and are appropriately placed in this setting. Special education teachers may also provide this instruction to a class of students with handicapping conditions in a special class setting.

Teachers certified in the subject area should become aware of the needs of those students with handicapping conditions participating in their classes. Instructional techniques and materials must be modified to the extent appropriate to provide students with handicapping conditions the opportunity to meet diploma requirements. Information or assistance is available through special education teachers, administrators, the CSE or a student's Individualized Education Program (IEP).

Strategies for Modifying Instructional Techniques and Materials

1. Prior to having a guest speaker or taking field trips, it may be helpful to structure the situation. Use of a checklist or a set of questions generated by the class will help students focus on relevant information. Accessibility for students with handicapping conditions should be considered when field trips are arranged.
2. The use of computer software may be appropriate for activities that require significant amounts of writing by students.
3. Students with handicapping conditions may use alternative testing techniques. The needed testing modifications must be identified in the student's Individualized Education Program. Both special and regular education teachers need to work in close cooperation so that the testing modifications can be used consistently throughout the student's program.
4. Identify, define and preteach key vocabulary. Many terms in this syllabus are specific and may need continuous reinforcement for some students with handicapping conditions. It would also be helpful to provide a list of these key words to the special education teacher in order to provide additional reinforcement in the special educational setting.
5. Check periodically to determine student understanding of lectures, discussions, demonstrations, etc. and how this is related to the overall topic. Encourage students to express their understanding. It may be necessary to have small group discussions or work with partners to determine this.
6. Provide students and special education teachers with a tape of lectures that contain substantial new vocabulary content and of guest speakers for further review within their special education classes.
7. Assign a partner for the duration of a unit to a student as an additional resource to facilitate clarification of daily assignments, timelines for assignments and access to daily class notes.
8. When assigning long-term projects/ reports, provide a timeline with benchmarks as indicators for completion of major project/report sections. Students who have difficulty with organizational skills and time sequence may need to see completion of sections to maintain the organization of a lengthy project/report.

Special education teachers providing this instruction must also become familiar with the goals and objectives of the curriculum. It is important that these teachers provide their students with the same or equivalent information contained in the curriculum.

Regardless of who provides the instruction, the cooperation between teachers of regular and of special education programs is essential. It is important for the students as well as the total school environment.

Alternative Testing Techniques

Another consideration in assisting students with handicapping conditions to meet the requirements of regular education is the use of alternative testing techniques. Alternative testing techniques are modifications of testing procedures or formats which provide students with handicapping conditions equal opportunity to participate in testing situations. Such

techniques provide the opportunity to demonstrate mastery of skills and attainment of knowledge without being limited or unfairly restricted by the existence of a handicapping condition.

The Committee on Special Education (CSE) is responsible for identifying and documenting a student's need for alternative testing techniques. This determination is made when a student is initially referred to CSE, is reviewed annually for as long as the student receives special education services, and is reviewed when the student is determined to no longer need special education services. **The modifications are to be used consistently throughout the student's educational program.** Principals ensure that students who have been identified by CSE as educationally handicapped are provided with the alternative testing techniques which have been recommended by CSE and approved by the Board of Education.

Alternative testing techniques which have been specified on student IEPs for use by a student must be used consistently in both special and regular education settings. Regular classroom teachers should be aware of possible alternative testing techniques and should be skilled in their implementation.

The coordination and cooperation of the total school program will assist in providing the opportunity for a greater number of students with a handicapping condition to meet the requirements needed to pursue a high school diploma. The integrated provision of regular education programs, special education programs, remediation, alternative testing techniques, modified teacher techniques and materials, and access to credit through alternatives will assist in enabling such students to pursue high school diplomas to a greater degree. The teacher who provides instruction through this curriculum has a unique opportunity to assist such students in their individual goals.

Additional information on alternative testing modifications is available in the manual entitled *Alternative Techniques for Students with Handicapping Conditions*, which can be obtained from:

New York State Education Department
Office for Education of Children with Handicapping Conditions
Room 1071 Education Building Annex
Albany, NY 12234

Infusing Awareness of Persons with Disabilities Through Curriculum

In keeping with the concept of integration, the following subgoal of the Action Plan was established:

> *In all subject areas, revisions in the syllabi will include materials and activities related to* generic subgoals such as problem solving, reasoning skills, speaking, capacity to search for information, the use of libraries and increasing student awareness of and *information about the disabled.*

The purpose of this subgoal is to ensure that appropriate activities and materials are available to increase student awareness of disabilities and issues in regard to disabilities.

This curriculum, by design, includes information, activities and materials regarding persons with handicapping conditions. Teachers are encouraged to include other examples as may be appropriate to their classrooms or the situation at hand. Teachers are also encouraged to assess the classroom environment to determine how the environment may contribute to student awareness of persons with disabilities.

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APPENDIX B

SYLLABUS – PROGRAM CORRELATION CHART
LEVEL II

		ACTIVITIES
	Time Emphasis (Days)	
INQUIRY SKILLS	CLASSIFYING	
	CREATING MODELS	
	FORMULATING HYPOTHESES	
	GENERALIZING	
	IDENTIFYING VARIABLES	
	INFERRING	
	INTERPRETING DATA	
	MAKING DECISIONS	
	MANIPULATING MATERIALS	
	MEASURING	
	OBSERVING	
	PREDICTING	
	RECORDING DATA	
	REPLICATING	
	USING NUMBERS	
LANGUAGE ARTS SKILLS/ PROCESSES	CLASSIFYING	
	DEVELOPING VOCABULARY	
	MANIPULATING IDEAS	
	QUESTIONING	
	RECORDING DATA	
	USING CUES	
	ACQUIRING INFORMATION	
	COMMUNICATING INFORMATION	
SCIENCE ATTITUDES	A. APPRECIATING, ENJOYING, NATURE	
	1. UNDERSTANDING, NATURAL WORLD	
	1.1 APPRECIATING NATURAL WORLD	
	1.11 COMPLEXITY, DIVERSITY, INTRICACY, ETC.	
	1.12 RESOURCE, HUMAN NEEDS	
	1.2 RESPECTING LIFE	
	1.21 INDIVIDUAL LIFE, PRECIOUS	
	1.22 SOURCE FOR CONTINUATION	
	1.23 AGING PROCESS	
	1.3 WANTING TO KNOW, UNDERSTAND	
	1.31 CONCEPTS, TERMS, TECHNIQUES, ETC.	
	1.32 ACCURATE INFORMATION	
	1.33 EXPLANATIONS, INTERPRETATIONS, PREDICTIONS	
	2. INVESTIGATIVE METHODS, NATURAL WORLD	
	2.1 SKEPTICISM, INVESTIGATION, REASONING	
	2.11 UNCERTAINTY OF INFORMATION, VERIFICATION	
	2.12 AMBIGUITY, CONTRADICTION, TENTATIVENESS	
	2.13 ORIGINAL INSIGHT, INFERENCES, ETC.	
	2.14 CAREFUL, SYSTEMATIC INVESTIGATION	
	2.15 LOGICAL REASONING, VALIDITY OF IDEAS	
	2.2 RESPECTING OTHERS, ENVIRONMENT	
	2.21 SAFETY	
	2.22 USE OF RESOURCES	
	2.23 CONTRIBUTING FAIR SHARE OF EFFORT	
	2.24 CONTRIBUTIONS, OTHERS	
	2.25 TRUTHFUL REPORTING	
	2.26 BELIEFS AND VALUES OF OTHERS	
	B. VALUING USE OF KNOWLEDGE FOR SOCIETY	
	1. THE PRACTICAL, TECHNICAL	
	1.1 SCIENTIFIC TECHNIQUES, MATERIALS	
	1.2 RESOURCEFULNESS, INNOVATIVENESS	
	1.3 TECHNIQUE EFFICIENCY, SIMPLICITY, ETC.	
	2. SERVICE THROUGH TECHNOLOGY	
	2.1 NEEDS, PROBLEMS OF OTHERS	
	2.2 BENEFITS OF TECHNOLOGICAL CHANGE	
	2.3 POTENTIAL ADVERSE CONSEQUENCES	

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LIFE SCIENCE (LEVEL II)	IIA. PLANTS, ANIMALS, NEW GENERATIONS
	1. FLOWERS, SUFFICIENT SEEDS, SURVIVAL, NEW GENERATION
	1.1 GENERATION, STAGES, LIFE CYCLE
	1.2 FLOWERS, SEEDS
	1.21 POLLEN TRANSFER, SEEDS
	1.22 POLLEN TRANSFER AIDS
	1.23 SEEDS, FRUIT
	1.3 SEED CHARACTERISTICS, SURVIVAL
	1.31 DISPERSAL
	1.32 SEVERE CONDITIONS, TEMPERATURE, DROUGHT
	1.33 GERMINATION, SUITABLE CONDITIONS
	1.34 STORED FOOD
	1.4 OTHER STRUCTURES, OFFSPRING
	1.5 PLANT POTENTIAL FOR OFFSPRING
	1.51 NUMBERS OF FLOWERS, SEEDS
	1.52 ACTUAL CONDITIONS, SURVIVAL, POPULATION
	2. ADULT ANIMALS, SUFFICIENT YOUNG, SURVIVAL, NEW GEN.
	2.1 GENERATION, STAGES, LIFE CYCLE
	2.2 CARE FROM ADULTS, LIVE, THRIVE
	2.3 YOUNG ANIMALS, LIVE, THRIVE, INDEPENDENT
	2.4 ANIMAL POTENTIAL FOR OFFSPRING
	2.41 ACTUAL CONDITIONS, SURVIVAL, POPULATION
	IIB. DIFFERENT KINDS, PLANTS, ANIMALS, DEPENDENCY, COMMUNITY
	1. PLANTS, ANIMAL FOOD SUPPLY, SUN ENERGY
	1.1 FOOD CHAIN
	1.2 FOOD WEB
	2. POPULATION SIZE, DEPENDENCIES, FOOD
	2.1 ANIMAL POPULATION, FOOD SUPPLY
	2.2 ANIMAL POPULATION CHANGE, FOOD SUPPLY CHANGES
PHYSICAL SCIENCE (LEVEL II)	IIC. ENERGY, MATERIAL, FORMS, PROPERTIES
	1. OBJECT PROPERTIES, FORMS, AMTS., PROP. OF MATERIALS
	1.1 OBJECT PROPERTIES, FORM
	1.11 SHAPE
	1.12 SOLID, LIQUID, GAS
	1.13 SIZE OF CONTAINED SOLID PARTICLES
	1.2 OBJECT PROPERTIES, AMOUNT OF MATERIAL
	2. ENERGY FORM, AMOUNT, ABILITY TO MOVE
	2.1 ENERGY FORMS
	2.2 ENERGY MOVEMENT, BETWEEN, THROUGH
	2.3 ENERGY, AMOUNTS AVAILABLE
	IID. INTERACTIONS, MATERIALS, ENERGY, SYSTEMS
	1. ENERGY CHANGES, INTERACTIONS
	2. ENERGY TRANSFER, SYSTEM
	3. ENERGY, INTERACTION, OBJECT PROPERTIES

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